RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA

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THE GEOLOGICAL SURVEY OF INDIA.

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1937.

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FIG. 2.—*Weichselia reticulata*. [K33/731.]

FIG. 3.—*Weichselia reticulata*. [K33/733.]

FIG. 4.—*Weichselia reticulata*. × 3. [K33/731.]

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FIG. 3.—Same specimen. Lateral view, showing 'dorso-ventral' ridge and acute middle lobe of the preserved end of the specimen.

PLATE 26.—Geological map of parts of the Shan States and Yunnan. (Scale 1 inch= 32 miles.)

MGIPC—M—VIII-4·1—25-10-37—800.

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 1.] 1936 [April.

GENERAL REPORT OF THE GEOLOGICAL SURVEY OF INDIA FOR THE YEAR 1935. BY A. M. HERON, D.Sc., F.G.S., F.R.G.S., F.R.S.E., F.A.S.B., *Director, Geological Survey of India.*

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DISPOSITION LIST.

DURING the period under report the officers of the Department were employed as follows:—

Superintendents.

DR. A. M. HERON . Returned from the field on the 31st March, 1935. Left for Kashmir on the 16th May, 1935, and returned on the 15th June, 1935. Continued in charge of the Northern Circle till the 17th September, 1935. Appointed to officiate as Director from the 18th September to the 7th November, 1935, *vice* Sir Lewis L. Fermor on leave preparatory to retirement, and confirmed in that appointment from the 8th November, 1935. Investigated the correlation of the

Tertiary rocks along the north-east edge of the Pinjor and Nalagarh *duns* from the 26th September to the 13th October, 1935.

DR. C. S. FOX . . Left for field work in Assam on the 15th January, 1935, and returned on the 14th April, 1935. Visited Nunidih-Jitpur colliery, Jharia coalfield, between the 18th and 20th July, 1935. Inspected the Saranda Tunnel of the Bengal Nagpur Railway on the 30th July, 1935. Investigated the problem of the drinking water supplies for the East Indian Railway at Madhupur on the 23rd October, 1935. Visited the Kalaktambi mica mine near Kodarma on the 15th November, 1935. Continued in charge of the Southern Circle till the 17th September, 1935, and thereafter placed in charge of the Northern Circle. Left for Assam on the 30th November, 1935, and returned on the 28th December, 1935. Investigated the danger of subsidence and flooding after underground fires, in seams XI and XII to the west of the Kari Jor, Jharia coalfield, on the 29th December, 1935.

MR. E. L. G. CLEGG . Left for Myitkyina on the 2nd January, 1935, and returned to Rangoon on the 7th January, 1935. Left for field work in Thayetmyo on the 8th January, 1935, and returned to Rangoon on the 21st February, 1935. Continued the large scale geological survey of the Mogok Stone Tract and left for the field on the 13th March, 1935, and returned to Yenangyaung on the 22nd May, 1935. In addition to charge of the Burma Circle, took over

charge of the office of the Resident Government Geologist, Yenangyaung, from the 22nd April, 1935, *vice* Mr. E. J. Bradshaw on leave. Left Yenangyaung for Rangoon on the 11th June, 1935, and returned to Yenangyaung on the 18th June, 1935. Left Yenangyaung for Rangoon on the 20th August, 1935, and for Calcutta on the 22nd August, 1935. Left Calcutta on the 8th September, 1935, and returned to Rangoon on the 10th September, 1935, and to Yenangyaung on the 15th September, 1935. Left Yenangyaung for field work in Thayetmyo on the 4th November, 1935, and returned on the 17th November, 1935. Left Yenangyaung on the 26th November, 1935, and returned on the same date. Made over charge of the office of the Resident Government Geologist, Yenangyaung, to Mr. E. J. Bradshaw on the 10th December, 1935. Left Yenangyaung on the 10th December, 1935, and returned to Rangoon on the 12th December, 1935.

Assistant Superintendents.

MR. H. CROOKSHANK . Granted combined leave out of India for 6 months and thirteen days, and availed himself of the same from the 3rd May, 1935, from the field. Returned from leave and resumed duty on the 17th November, 1935. Appointed Superintendent from the 8th November, 1935. Placed in charge of the Southern Circle from the 17th November, 1935, and left for field work in the Central Provinces and Madras on the 21st December, 1935.

Mr. E. J. Bradshaw . Continued as Resident Government Geologist, Yenangyaung, and official member of the Advisory Board of the Yenangyaung and Singu oilfields till the 22nd April, 1935. Granted combined leave out of India for 7 months and 15 days, from the 23rd April, 1935. On return from leave, attached to the Burma Circle and assumed charge of the duties of the Resident Government Geologist, Yenangyaung, on the 10th December, 1935.

Dr. A. L. Coulson . Returned from leave and resumed duty on the 28th June, 1935. Appointed Curator of the Geological Museum and Laboratory from the 11th July to the 17th September, 1935. Appointed to officiate as Superintendent from the 18th September to the 7th November, 1935, *vice* Dr. A. M. Heron officiating as Director, and from the 8th to the 16th November, 1935, *vice* Mr. H. Crookshank on leave; placed in charge of the Southern Circle during that period. Attached to the Northern Circle for work in the North-West Frontier Province and South Waziristan.

Mr. D. N. Wadia . Continued to act as Palæontologist till the 6th March, 1935. Granted leave out of India on average pay for 8 months from the 7th March, 1935. Returned from leave and resumed duty on the 11th November, 1935. Attached to the Northern Circle for work in Kashmir.

Dr. J. A. Dunn . . Returned from leave and resumed duty on the 15th September, 1935. Appointed Curator of the Geological

Museum and Laboratory from the 18th September, 1935. Visited Kamptee in connection with the borehole water supply scheme between the 27th and 29th September, 1935.

MR. C. T. BARBER . Retired from service from the 17th July, 1935.

MR. E. R. GEE . . Continued in charge of Office as Assistant Director. Appointed Palæontologist from the 7th March to the 20th May, 1935. Visited the Punjab Salt Range from the 27th September to the 15th October, 1935.

MR. W. D. WEST . Left for field work in the Central Provinces, Rewa State and the Simla Himalayas on the 1st February, 1935, and left Simla for Quetta on the 7th June, 1935, to investigate the Quetta earthquake. Returned to Simla on the 6th July, 1935, and to headquarters on the 14th July, 1935. Attached to the Southern and Northern Circles for work in the Central Provinces and the Simla Himalayas respectively.

DR. M. S. KRISHNAN . Continued to act as Curator of the Geological Museum and Laboratory till the 10th July, 1935. Granted combined leave out of India for 1 year and 4 months from the 11th July, 1935.

MR. J. B. AUDEN . Returned from the field on the 9th July, 1935. Granted leave on average pay from the 14th October to the 12th November, 1935. Attached to the Northern Circle for work in the Mussoorie Himalayas.

MR. V. P. SONDHI . Returned to Rangoon on the 6th June, 1935. Left for recess in Calcutta on the 11th June, 1935. Attached to the Burma Circle and left for Rangoon to

continue the survey of the Southern Shan States on the 27th October, 1935. Left for the field on the 17th November, 1935.

Extra Assistant Superintendents.

DR. H. L. CHHIBBER . Returned to Rangoon from field work in the Myitkyina district on the 9th January, 1935. Granted leave on medical certificate on half average pay for 2 months and 4 days combined with leave "not due" for 1 month and 26 days from the 5th March to the 4th July, 1935. Promoted to the grade of Assistant Superintendent from the 1st April, 1935. Resigned the service from the 5th July, 1935.

DR. P. K. GHOSH . Returned from leave and resumed duty on the 17th February, 1935. Attached to the Southern Circle for work in Madras and in the Central Provinces. Left for the field on the 4th March, 1935, and returned on the 3rd May, 1935. Promoted to the grade of Assistant Superintendent from the 1st April, 1935. From the 25th August to the 21st September, 1935, visited the occurrences of natural gas at Gogha, Kathiawar, and at Hajad, Broach and Panch Mahals district, and also investigated the limestone deposits of Surat district. Attached to the Southern Circle for work in the Central Provinces and in Madras and left for the field on the 27th November, 1935.

DR. M. R. SAHNI . Returned from the field to Rangoon on the 12th May, 1935. Promoted to the grade of Assistant Superintendent from the 1st April, 1935. Transferred from

	Burma to India and left Rangoon for Calcutta on the 16th May, 1935. Appointed Palæontologist from the 21st May, 1935.
MR. D. BHATTACHARJI .	Returned from the field on the 18th November, 1935. Attached to the Southern Circle for work in the Central Provinces, and left for the field on the 13th November, 1935.
MR. B. C. GUPTA .	Attached to the Southern Circle for work in the Central Provinces, and left for the field on the 25th November, 1935.
MR. H. M. LAHIRI .	Returned from the field on the 28th April, 1935. Granted leave on average pay for 1 month and 12 days from the 13th June to the 24th July, 1935. Attached to the Northern Circle for work in the Punjab. Granted leave on average pay for 1 month and 13 days from the 11th November, 1935, with permission to affix the Christmas and New Year holidays.
DR. L. A. N. IYER .	Returned from the field to Rangoon on the 4th May, 1935. Left for recess in Calcutta on the 7th May, 1935. Attached to the Burma Circle for work in the Amherst district and left for the field on the 12th November, 1935.
MR. P. N. MUKERJEE .	Returned from the field on the 22nd April, 1935. Granted combined leave for 2 years from the 19th September, 1935.
DR. A. K. DEY . .	Returned from the field on the 1st May, 1935. Services transferred to Jashpur State on foreign service from the 1st November, 1935.
MR. A. M. N. GHOSH .	Left for the field on the 16th January, 1935, and returned on the 19th May, 1935. Promoted to the grade of

Assistant Superintendent from the 7th December, 1935. Attached to the Northern Circle for work in Assam.

Artist.

MR. S. RAY . . Remained at headquarters. Granted leave on average pay for 20 days from the 14th October, 1935.

Assistant Curator.

P. C. ROY . . Granted leave on average pay from the 2nd January to the 5th February, 1935. At headquarters.

Field Collectors.

N. K. N. AIYENGAR Left for the field to collect fossil reptile remains in Rewa and Hyderabad States on the 2nd March, 1935, and returned on the 16th April, 1935. Services transferred to Dr. H. De Terra on foreign service from the 1st May to the 26th September, 1935. From the 27th September to the 16th December, 1935, collected specimens from the Punjab.

A. B. DUTT . . At headquarters.

Assistant Chemist.

MAHADEO RAM . At headquarters. Granted leave on average pay from the 13th May to the 11th June, 1935.

Chemical Assistant.

L. R. SHARMA . Continued to act as Chemical Assistant to the Burma Circle during the period under report.

Museum Assistants.

D. GUPTA . . . . At headquarters. Granted leave on average pay from the 19th January to the 18th April, 1935.

M. S. VENKATRAM . At headquarters.

V. BHASKARA RAO . At headquarters. Granted combined leave from the 30th April to the 28th June, 1935.

2. The cadre of the Department, at the end of the year, consisted of 3 Superintendents and 13 Assistant Superintendents.

ADMINISTRATIVE CHANGES.

Promotions and appointments.

3. Dr. A. M. Heron officiated as Director from the 18th September, to the 7th November, 1935, *vice* Sir Lewis L. Fermor, Kt., on leave, and was confirmed in the appointment of Director with effect from the 8th November, 1935.

Mr. H. Crookshank was promoted to the grade of Superintendent with effect from the 8th November, 1935, *vice* Dr. A M. Heron. Dr. A. L. Coulson officiated as Superintendent from the 18th September to the 7th November, 1935, *vice* Dr. A. M. Heron officiating as Director, and from the 8th to the 16th November, 1935, *vice* Mr. H. Crookshank on leave.

Drs. H. L. Chhibber, P. K. Ghosh and M. R. Sahni were promoted to the grade of Assistant Superintendent with effect from the 1st April, 1935. Mr. A. M. N. Ghosh was promoted to the grade of Assistant Superintendent with effect from the 7th December, 1935.

Dr. M. S. Krishnan was Curator of the Geological Museum and Laboratory till the 10th July, 1935, when he was relieved by Dr. A. L. Coulson. From the 18th September, 1935, Dr. J. A. Dunn was Curator.

Mr. D. N. Wadia continued as Palæontologist till the 6th March, 1935, when he was relieved by Mr. E. R. Gee. From the 21st May, 1935, Dr. M. R. Sahni was Palæontologist.

Retirements and resignation.

4. Sir Lewis L. Fermor, Kt., retired from the service with effect from the 8th November, 1935.

Mr. C. T. Barber retired from the service with effect from the 17th July, 1935.

Dr. H. L. Chhibber resigned the service with effect from the 5th July, 1935.

Leave.

5. Sir Lewis L. Fermor, Kt., was granted leave on average pay for one month and twenty-one days with effect from the 18th September, 1935, with permission to retire on the expiry of the leave.

Mr. H. Crookshank was granted leave out of India on average pay for three months combined with leave on half average pay for three months and thirteen days with effect from the 3rd May, 1935.

Mr. E. J. Bradshaw was granted leave out of India on average pay for four months combined with leave on half average pay for three months and fifteen days with effect from the 23rd April, 1935.

Mr. D. N. Wadia was granted leave out of India on average pay for eight months with effect from the 7th March, 1935.

Dr. M. S. Krishnan was granted leave out of India on average pay for five months combined with study leave for eleven months with effect from the 11th July, 1935.

Mr. J. B. Auden was granted leave on average pay for one month with effect from the 14th October, 1935.

Dr. H. L. Chhibber was granted leave on medical certificate on half average pay for two months and four days combined with leave 'not due' for one month and twenty-six days with effect from the 5th March, 1935.

Mr. H. M. Lahiri was granted leave on average pay for one month and twelve days with effect from the 13th June, 1935, and again for one month and thirteen days with effect from the 11th November, 1935.

Mr. P. N. Mukerjee was granted leave out of India on average pay for eight months, combined with leave on half average pay for four months and study leave for twelve months with effect from the 19th September, 1935.

OBITUARY.

6. James Malcolm Maclaren died on the 14th March, 1935. Dr. Maclaren joined the Geological Survey of India as a Mining Specialist on the 29th October, 1902, and resigned therefrom on the 9th October, 1906. An obituary notice has been published in *Records, Geol. Surv. Ind.*, Vol. LXIX, pp. 385-386.

HONOURS AND AWARDS.

7. The title of Knighthood was conferred on Dr. L. L. Fermor, Director, Geological Survey of India, on the occasion of the King-Emperor's Birthday in 1935.

8. The Government of India Prize of Rs. 500 awarded annually by the Council of the Mining and Geological Institute for 'the best paper by a member read before the Institute and published in the *Transactions* each year' was awarded for the year ending the 31st October, 1935, to Professor C. Forrester, Indian School of Mines, for his paper entitled 'A Study of the Barakar Coals of the Jharia Coalfield'.

LECTURESHIP.

9. Dr. M. S. Krishnan continued to act as a part-time Professor of Geology at the Presidency College, Calcutta, till the 27th June, 1935, and thereafter Dr. A. L. Coulson.

POPULAR LECTURES.

10. The following popular lectures were delivered by officers of the Department during the year:—

(1) 'The Movement of Underground Waters, including radio-active waters and mineral springs' by Dr. C. S. Fox before a meeting of the Mining and Geological Institute of India held at Dhanbad.

(2) 'On Meteorites' by Dr. A. L. Coulson at the Presidency College, Calcutta, and before a meeting of the Mining and Geological Institute of India held at Dhanbad.

(3) 'The Quetta Earthquake of 1935' by Mr. W. D. West at the joint meeting of the Mining and Geological Institute of India and the Manbhum Branch of the European Association held at Jharia.

(4) 'Work and Play in the Himalaya' by Mr. J. B. Auden at the Presidency College, Calcutta.

(5) 'Earthquakes' (four lectures) by Mr. J. B. Auden at the Patna University.

(6) 'Recent Indian Earthquakes' by Dr. A. M. Heron at the Rotary Club, Calcutta, and as a Presidential Address to the Calcutta Geographical Society.

(7) 'On a recent visit to Abyssinia' by Dr. C. S. Fox at the Institution of Engineers (India), Calcutta.

11. At the request of the Principal, Indian School of Mines, Dhanbad, Mr. E. R. Gee prepared a report on 'Suggested tours in the Punjab Salt Range' for the use of the students of the School during their annual excursions to that area.

Suggested tours in Salt Range, Punjab.

CENTENARY CELEBRATIONS OF THE GEOLOGICAL SURVEY OF GREAT BRITAIN.

12. Sir Lewis L. Fermor, Kt., O.B.E., D.Sc., F.R.S., representing the Trustees of the Indian Museum, Calcutta, sent a Congratulatory Address to the Director of the Geological Survey of Great Britain on the occasion of its Centenary Celebrations held in July, 1935.

13. Mr. H. Crookshank, Assistant Superintendent of this Department, delivered, while on leave in England, a Congratulatory Address on behalf of the Director and Officers of the Geological Survey of India to the Director of the Geological Survey of Great Britain on the above occasion.

CONGRESSES.

14. Mr. D. N. Wadia, while on leave in Europe, attended the Third International Congress of Soil Science held at Oxford, as a delegate from India. The plenary sessions of the Congress, from the 30th July to the 7th August, 1935, were followed by an excursion round Great Britain from the 8th to the 23rd August, 1935, during which a number of soil profiles of characteristic English, Welsh and Scottish soils were examined.

Among the more important contributions to the Congress, from an Indian point of view, were papers on soil genesis and cartography, soil-maps of different countries, aspects of tropical soils, and soil erosion. Representatives of 40 different countries of the world attended and a considerable volume of data and information on this comparatively new but vigorously growing science of pedology was exchanged. A number of typical soil samples and monoliths were exhibited showing their relation to the parent rock. Mr. Wadia has submitted a few notes on some of the subjects discussed of interest to Indian soil workers.

Mr. Wadia also attended the Second International Congress of Carboniferous Stratigraphy held at Heerlen in Holland, from the 9th to the 13th September, 1935. Interesting papers on the tectonics and stratigraphy of the Permo-Carboniferous of Eurasia and North

America were read and discussed. Other papers dealt with floral successions, correlations of different Carboniferous provinces, coal petrography, nomenclature of coal components and the question of the connection of Gondwanaland with the Angara continent.

PUBLICATIONS.

15. The following publications were issued during the year under report:—

1. Records, Vol. LXVIII, Part 4.
2. Records, Vol. LXIX, Part 1.
3. Records, Vol. LXIX, Part 2.
4. Records, Vol. LXIX, Part 3.
5. Memoirs, Vol. LXVI, Part 1.
6. Palæontologia Indica, New Series, Vol. XX, Memoir No. 5.

LIBRARY.

16. The additions to the library amounted to 3,326 volumes, of which 1,153 were acquired by purchase and 2,173 by presentation and exchange.

Rangoon Office.

17. During the year under review 107 volumes have been added to the library of the Burma Circle, of which 87 were purchased, 18 were official publications and two were received gratis.

DRAWING OFFICE.

18. Mr. S. Ray was in charge of the Drawing Office throughout the year, except for a period of twenty days from the 14th October, 1935, when he was on leave on average pay.

Publications.

19. During the year, 119 halftone and line blocks and 10 litho stones were prepared for plates of the Records, Memoirs and Palæontologia Indica, and 64 plates were printed off, 83 drawings and diagrams and 78 line blocks for text-figures were also made.

20. The number of geologically coloured originals received from officers totalled 41, while 1,932 topographical sheets were received from the Director, Map Publication, Survey of India, and 787 were issued for departmental use.

21. The photographic section was fully occupied with copying, developing and printing work for publications and reports. The

number of negatives received into stock totalled 203, while 1,752 photographic prints were made. In addition, 181 lantern slides were made.

Photographic section.

MUSEUM AND LABORATORY.

22. Dr. M. S. Krishnan continued as Curator of the Geological Museum and Laboratory until his departure on leave on 11th July, 1935, when the duties were taken over by Dr. A. L. Coulson pending the return of Dr. J. A. Dunn from leave. Dr. Dunn acted as Curator from the 18th September, 1935, until the end of the year.

23. Babu Purna Chandra Roy continued as Assistant Curator throughout the year. Babu Dasarathi Gupta, M. R. Ry., M. S. Venkatram and V. Bhaskara Rao continued to work as Museum Assistants. V. R. Khedker held the post of temporary Museum Assistant from 13th May, 1935, to 26th September, 1935. Babu Mahadeo Ram continued as Assistant Chemist throughout the year.

24. The number of specimens determined in the laboratory amounted to 687, of which 67 were quantitatively analysed or otherwise specially tested. The corresponding figures for the previous year were 620 and 105 respectively. Much of the analytical work was of a specialised character, such as the analyses of manganese minerals and of vanadium-bearing ores.

25. In the absence of a Chemist the department continues to work under difficulties. As in previous years it has been necessary to send certain materials elsewhere for analysis, although the laboratory is well equipped to undertake analyses of varied types.

26. Presentations of collections of rocks and minerals were made to the following institutions during the year :—

Donations to institutions, etc.

1. St. Xavier's College, Cruickshank Road, Bombay.
2. Yale University, New Haven, U. S. A.
3. Department of Geology and Geography, University College, Rangoon.
4. C. M. S. High School, Bhagalpur.
5. Nadirshaw Edulji Dinshaw Civil Engineering College, Karachi.
6. Department of Geography, University of Madras.
7. Government High School, Wun, Berar.
8. All India Institute of Hygiene and Public Health, Calcutta.
9. St. John's College, Agra.

27. The following special presentations were made :—

1. Bauxite and laterite to A. K. Bose, Esq., Sardarpur P. O., *via* Vijapur, Baroda State Ry.
2. Photomicrographs and specimens of mica to G. H. Tipper, Esq., India House, London.
3. Bundelkhand gneiss to P. Venkayya, Esq., Kurnool, Madras.
4. Manganese minerals, triplite, samarskite, etc., to Dr. Karl Chudoba, Bonn University, Germany.
5. Chipped flints, supposed to be implements, to T. T. Paterson, Esq., Yale University Expedition.

Addition to the collections.

28. In addition to the usual collections of minerals and rocks made by officers during the year, the following material was also presented to the Department :—

1. Water-worn pebble found embedded in coal from Umaria, presented by the Manager, Umaria State Collieries, Rewa State.
2. Rock specimens illustrating the geology of the Appalachian Region, by exchange with Yale University.
3. New Zealand coals, presented by the Director, Geological Survey of New Zealand.
4. Coal specimens, presented by the Geological Survey of New South Wales.
5. Chrome-ore from Japan, presented by Mr. A. L. Shrager.
6. Beryl and barytes from Rajputana, presented by Mr. K. L. Bhola.
7. Columbite, pitchblende, monazite, beryl and mica from Gaya district, presented by Mr. P. F. Thomas, Calcutta.
8. Banded manganese-ore from Singbhum, Bihar and Orissa, presented by Dr. E. Spencer, Calcutta.
9. Serpentine from near Chaibasa, presented by the Secretary, Automobile Association of Bengal, Calcutta.
10. Kaolin from Manbhum, Bihar and Orissa, presented by Captain B. K. Joshi, Calcutta.
11. Garnet from Hazaribagh, Bihar and Orissa, presented by Mr. K. K. Sen Gupta, Calcutta.
12. Tourmaline from Ajmer-Merwara, presented by Mr. K. K. Sen Gupta, Calcutta.
13. A huge crystal of quartz from Nepal, purchased.

29. Specimens have been recovered from two meteoric showers during the year 1935, both of which, strangely enough, fell in the Tippera district of Bengal, some 17 miles apart, the second shower occurring after a lapse of some 2½ months.

Meteorites.

The first shower fell in the vicinity of Perpeti (23° 19′ : 91° 0′) and other villages under the jurisdiction of Chandina and Kachua Police Stations, at about 11 P.M. on the 14th May, 1935, 14 specimens being recovered from a rectangular area five miles by three miles. The apparent direction of flight of the parent meteorite was from south-west to north-east in the direction of the shorter rectangular side. The fall was accompanied by the usual phenomena of light and sound. The largest stone, which fell at the village Perpeti that gives its name to the shower, weighed 6,869·85 grammes. The total weight recovered amounted to 23,474·18 grammes. The meteorite is a white chondrite, Cw in Brezina's classification, with a white, rather friable, mass with scarce, mostly white, chondrules. In Prior's classification, the Perpeti fall belongs to the Baroti and Soko-Banja types, hypersthene-olivine-chondrites. Its specific gravity is 3·554. The meteorite has been analysed and its description will be published in a paper by Dr. A. L. Coulson to appear in these *Records*.[1]

The second shower fell at about 2-20 P.M. on the 29th July, 1935, in the vicinity of Patwar village (23° 9′ : 91° 11′), 1½ miles south of Nangalkot railway station and 20 miles south of Comilla, covering a rectangular area of about 4½ square miles, the longer side of which was in the direction of flight (E.N.E. to W.S.W.) of the parent meteorite. The fall was accompanied by the usual phenomena of light and sound, the sound being heard at Chaudda-gram, some seven miles away from the nearest village from which specimens were recovered. The largest specimen, weighing 23,111·6 grammes, penetrated the ground to a depth of 34 inches. According to Brezina's classification, taking into account Prior's investigation of those groups, the Patwar fall is classified as a mesosiderite (grahamite) (M) and so has added scientific interest. Its specific gravity is 4·21. A description of the meteorite has been published elsewhere.[2]

It appears probable that a meteorite fell towards the north-west near Muzaffarpur in north Bihar at about 8 P.M. on either the

[1] *Rec. Geol. Surv. Ind.*, 71, Pt. 2, (*in the Press*).
[2] A. L. Coulson, *op. cit.*, LXIX, Pt. 4, pp. 439–457, (1936).

8th or 9th August, 1935, but no traces of it have been found. The 'bright falling star' was also seen by residents of Darbhanga district.

Another meteorite probably fell towards the N.N.E. near Habiganj in the Sylhet district, Assam, at about 8 P.M. on the 4th November, 1935, but no specimens have been obtained. The locality in question is only 80 miles north of Patwar in the Tippera district, from which the Patwar fall above was recovered.

A report of a fall of a meteorite in a paddy field near the golf course at Shillong turned out to be a case of lightning splitting a tree.

Rangoon Office.

30. In the laboratory of the Rangoon Office, Mr. L. R. Sharma continued his duties as Chemical Assistant to the Burma Circle. Up to the end of November, 1935, 26 specimens were received and reported upon, out of which 9 were quantitatively determined. The specimens examined included minerals and rocks from the Shan States and the Pyinmana district.

The Office of the Burma Circle has been moved from 593, Merchant Street back to the old quarters in 230, Dalhousie Street, Rangoon.

STRATIGRAPHY.

Ambala district, Punjab.

31. During the Pujah holidays in October, 1935, Dr. Heron investigated the correlation of the Tertiary rocks along the north-east edge of the Pinjor and Nalagarh *duns.* Originally these had been mapped as Nahan (Lower Siwalik) by H. B. Medlicott and R. D. Oldham, but Dr. G. E. Pilgrim had subsequently classified them as Dagshai. During this field-season Mr. H. M. Lahiri, having visited the type areas at Nahan (30° 34′ : 77° 17′, 53 F/6), Dagshai (30° 52′ : 77° 3′, 53 F/1) and Kasauli (30° 54′ : 76° 58′, 53 B/13), expressed doubts about Dr. Pilgrim's correlation and suggested a return to that of Medlicott and Oldham. Dr. Heron first examined the type sections at Nahan, Dagshai and Kasauli and then compared the disputed beds at Kalka (30° 50′ : 76° 56′, 53 B/13) and Nalagarh (31° 2′ : 76° 44′, 53 A/12) with them.

The Nahans at Nahan are predominantly soft greenish grey or drab sandstones weathering khaki with smooth surfaces and rounded edges; they are coarse and micaceous, in thick beds with little stratification and sparse jointing. The interbedded clays are subordinate, reddish brown in colour mottled with grey, and are often

nodular and pseudo-conglomeratic. The lowest beds in the section, thrust over the boulder conglomerates of the Upper Siwaliks, are quite different, and give rise to a striking polychrome cliff (2104) on the Markanda N. below Ambwala. They are brightly coloured reddish brown and purplish brown calcareous clays, with yellowish brown bands and pale blue-grey soft, crushed sandstones. Topping the cliff are seen the massive drab sandstones. A few feet above the thrust plane with the boulder conglomerates, which is coincident with the bedding dip of both formations above and below it, is a bed of powdered lignite one to four inches thick. Lignite was also seen by Mr. Lahiri in another section two miles to the west.

The Kasaulis at Kasauli are also predominantly a sandstone formation, perhaps even more so than the Nahans, and like the Nahans they are micaceous, and show little bedding, but an irregular jointing forming sharp-edged blocks, instead of the smooth slabs of the Nahans; they are harder and finer in grain, and usually of a darker grey than the Nahans, weathering brownish. The shales are hard, purplish brown, grey or olive and splinter, on weathering, into angular chips; at Kasauli itself they are quite subordinate, but are more developed lower down the scarp towards Kalka.

The Dagshais in the splendid sections along the roads radiating from Dharmpur to Kalka, Kasauli, Subathu, Dagshai and Simla, are principally shales and are distinctly red in the aggregate as a scenic feature. In detail the shales are reddish brown and purplish brown, mottled with grey; they are harder than either the Nahan clays or the Kasauli shales, and break up *in situ* into sharply angular fragments. Though the sandstones are subordinate in aggregate thickness to the shales, they are conspicuous because they give rise to rugged outcrops projecting above the shales. They are dark red and dark grey in colour, harder than the Kasaulis, and might be termed quartzites; they are irregularly jointed and show no stratification, but form massive beds six to twenty feet in thickness, sharply defined from the shales with which they are interbedded.

At a first glance the disputed beds at Kalka, which are well seen in the Koshalia N. *downstream* from the pumping station which supplies Kalka with water, have a resemblance to the Dagshais, due to their both being a predominantly argillaceous and reddish formation, but on a close examination it is clear that they resemble the lower Nahans of the Markanda N. cliff sections much

more closely. The true Dagshais are exposed as a band, over a mile wide, *upstream* from the pumping station, and are seen to pass upwards into the Kasaulis of the type area, a few miles along the strike from Kasauli itself. Between the disputed beds and the true Dagshais are Subathus and Infra-Blainis, but the distance separating them is only half a mile and we should expect close lithological resemblance if they are the same. This however is not the case. The reddish brown colour of the Dagshai shales is on the whole brighter, more definitely a red, and is more uniform than the varied tints of the disputed beds. The Dagshai sandstones (or quartzites) are either dark reddish brown or dark grey, and do not differ much from the interbedded shales in colour, except that they are duller.

The disputed beds are markedly colour-banded. The clays are reddish brown and purplish brown, banded with yellowish brown, and the soft sandstones interbedded with them are a clear blue-grey in colour, sometimes almost white, and are often associated with pale lavender clays. Pseudo-conglomerates of clay-balls, as in the Markanda sections and fine true conglomerates occur in them Neither Mr. Lahiri nor Dr. Heron saw any of these in the Dagshais. These pale crushed sandstones are abundantly interbedded with the clays and assist in giving the characteristic banded effect. Besides them, there are in the Koshalia N. section soft grey sandstones weathering khaki, in more massive beds which resemble the upper or typical Nahans forming the ridge at Nahan itself.

The most marked difference between the disputed beds and the Dagshais in these closely adjacent sections is however in their degree of induration, which is in both cases the same as that of the Nahans and Dagshais respectively in their type areas. In the disputed beds the sandstones are soft, often crushed and are denuded equally with the clays, so that they do not project as the hard quartzitic Dagshai sandstones do, forming sharp-edged ledges and reefs. The Dagshai shales are hard and splintery, whereas the argillaceous beds of the others are merely clays. The scarps of the disputed series are scored and fluted by rain-wash, giving earth-pillars, after the manner of the incoherent Siwaliks and unlike the more resistant Kasaulis and Dagshais.

In the Nalagarh area, Dr. Pilgrim shows on his map a band of Dagshais running east of Nalagarh, with Nahans or Kasaulis (the same colour being used for both) on both sides of it.

A curving fault passing through Nalagarh is shown as separating his 'Dagshai' belt from the lower Nahans or Kasaulis to the west of the belt, while a normal passage takes place from the 'Dagshais' to the lower Nahans or Kasaulis to the east of the belt. Neither Mr. Lahiri nor Dr. Heron could see any difference between the rocks on each side of the fault and both are identical with the disputed beds near Kalka and the colour-banded clays of the Markanda N. sections below Nahan.

In the Chikni N., two miles north of Nalagarh, excellent sections are seen of the characteristic reddish, purplish and yellowish brown banded clays and blue-grey crushed sandstones.

In describing the lower Koshalia N. section, mention was made of massive soft grey, khaki-weathering sandstones strongly resembling the Nahans which form the ridge at Nahan. In the Chikni N. section these have become more important and there are three groups of them near the top of the colour-banded clays, each group consisting of several thick beds and forming a minor ridge, uniting to form that above Nalagarh. They contain coaly vegetable remains and pseudo-conglomerates as below Nahan. These pass upwards conformably into reddish brown mottled nodular clays, not colour-banded, having in them soft purplish and grey khaki-weathering sandstones. Both clays and sandstones are typical Nahans of the Nahan ridge and are much softer than the Kasaulis, with which Dr. Pilgrim correlated them in his summaries of field-notes on the ground that they contained fossil wood, but the clays seem to be in a higher proportion with regard to the sandstones than in the sections below Nahan; this may however be due to the higher dips in the Nahan sections tending to obscure the clays. In these, Mr. Lahiri found unidentifiable vertebrate remains near Bairian, two miles east of Nalagarh. They pass upwards into massive typical Nahan sandstones forming the ridge Δ 3029 near Pannar Moti, 3½ miles east of Nalagarh.

In the previous field season, Mr. Lahiri drew Dr. Heron's attention to, and he examined, reddish and purplish brown clays with yellowish brown bands underlying typical ridge-forming Nahan sandstones (mapped by Dr. Pilgrim as Nahan) in the Sola Singhi ridge, Δ 3812, over fifty miles to the north-west of Nalagarh. There is little doubt that here also we have ridge-forming Nahan sandstones underlain by the colour-banded lower Nahan clays.

PALAEONTOLOGY.

32. Mr. D. N. Wadia acted as Palæontologist till the 6th March, 1935, when he went on leave. Mr. E. R. Gee held charge from the 7th March to the 20th May. Dr. M. R. Sahni continued as Palæontologist from the 21st May till the end of the year. Mr. A. B. Dutt, Field Collector and Babu D. Gupta, Museum Assistant, assisted the Palæontologist with routine work during the year.

33. During 1935, the following memoir was published in the *Palæontologia Indica* :—

(1) L. R. Cox : 'The Triassic, Jurassic and Cretaceous Gastropoda and Lamellibranchia of the Attock District,' Memoir No. 5, Vol. XX of the New Series.

The following papers of palæontological interest have appeared in the *Records* :—

(1) L. F. Spath : 'On a Turonian Ammonite (*Mammites daviesi*) from Ramri Island, Burma', (Vol. LXVIII, Pt. 4).
(2) M. R. Sahni : 'On the probable Underground Occurrence of Tertiary Rocks near Puri', (Vol. LXVIII, Pt. 4).
(3) D. N. Wadia : 'On the Cretaceous and Eocene fossils in the volcanic rocks of the Great Himalaya range, Burzil, North Kashmir', (Vol. LXVIII, Pt. 4).
(4) Frederick Chapman : 'Primitive Fossils, possibly Atrematous and Neotrematous Brachiopoda, from the Vindhyans of India', (Vol. LXIX, Pt. 1).
(5) H. Crookshank : 'Note on some Jabalpur Plants from the Satpura Gondwana Basin', (Vol. LXIX, Pt. 2).
(6) H. S. Rao : '*Rhizomopsis*, Gothan and Sze, and *Dictyopteridium*, Feistmantel', (Vol. LXIX, Pt. 2).
(7) H. S. Rao : 'On a Sphaerosiderite, containing a new species of *Dadoxylon*, (*D. parbeliense*) from the Lower Gondwana Coal Measures of India', (Vol. LXIX, Pt. 2).

34. The following papers of palæontological interest are in the Press and are expected to be published in 1936 :—

Palæontologia Indica.

(1) F. R. Cowper Reed : 'The Lower Palaeozoic Fauna from the Southern Shan States', Memoir No. 3, Vol. XXI of the New Series.

(2) L. Rama Rao and Julius Pia: 'Fossil Algae from the Uppermost Cretaceous beds (Niniyur group) of the Trichinopoly District, Madras', Memoir No. 4, Vol. XXI of the New Series.

(3) L. R. Cox: 'Fossil Mollusca from Southern Persia (Iran) and Bahrein Island', Memoir No. 2, Vol. XXII of the New Series.

(4) L. F. Spath: 'On Bajocian Ammonites and Belemnites from Eastern Persia (Iran)', Memoir No. 3, Vol. XXII of the New Series.

(5) J. A. Douglas: 'A Permo-Carboniferous Fauna from South West Persia (Iran)', Memoir No. 6, Vol. XXII of the New Series.

(6) F. R. Cowper Reed: 'Some Fossils from the *Eurydesma* and *Conularia* Beds (Punjabian) of the Salt Range', Memoir No. 1, Vol. XXIII of the New Series.

Records.

(1) M. R. Sahni: '*Fermoria minima*: A revised classification of the organic remains from the Vindhyans of India', (Vol. LXIX, Pt. 4).

Vertebrates.

35. Casts of some primate teeth, as also the cast of a stegodon molar tooth, were supplied to Mons. P. Revilliod of the Museum d' Histoire Naturelle, Geneva. A similar request from the Director, Colombo Museum, for the cast of the palate of *Palæopithecus sivalensis* Lyd. was also complied with.

At the request of Mr. Beni Chandra Mahendra of St. John's College, Agra, a detailed examination of the vertebrae of the fossil snake and lizard specimens included in our collection was undertaken by the Palæontologist.

Mr. N. K. N. Aiyengar made a fine collection of Triassic reptilian fossils from Maleri in the Pranhita-Godavery valley, Hyderabad State and from Tiki in south Rewa. At the suggestion of Dr. C. A. Matley, these fossil bones have been sent to Prof. Von Heune for examination.

On a request from Dr. G. E. Pilgrim, a further collection consisting of bovine skulls and a broken sacral vertebra of probably the ox, presented to this Department by Dr. B. Prashad, Director

of the Zoological Survey of India, has been sent to him for investigation. Dr. Pilgrim has undertaken the preparation of a memoir on the fossil Bovidae of India, which is nearing completion.

Some specimens of fossil fish collected by Mr. Crookshank from the Intertrappeans of Betul and Hoshangabad districts in the Central Provinces have been submitted to Dr. S. L. Hora, of the Zoological Survey of India, for examination and report.

Invertebrates.

36. On a request from Prof. L. Rutten of the University of Utrecht (Netherlands) a specimen of rock containing *Dalheidia haydeni* (Type No. 12/809) described by Prof. Douvillé[1] of Paris, along with Cretaceous fossils from Central Tibet, was sent to him for comparison with *Torreina*, gen. nov., described from the Upper Cretaceous of Cuba. Prof. Rutten is doubtful regarding the affinities of *Dalheidia* but he is of opinion that there are real differences between *Dalheidia* and *Torreina*—the initial chambers being absolutely different.

Specimens of *Venericardia beaumonti* have been presented to Dr. R. Rutsch, Keeper of the Geological and Palaeontological Section of the Musée d'histoire naturelle, Basle, Switzerland.

A collection of ammonities and belemnites from the probable uppermost Jurassic beds of the western end of the Salt Range and from the Chichali pass and Makerwal areas of the Trans-Indus range, made by Mr. E. R. Gee during the last two field seasons in the Punjab, has been sent to Dr. L. F. Spath of the British Museum (Natural History) for examination.

The specimen of *Lockhartia* (*Dictyoconoides*) *tipperi*, which Lt.-Col. L. M. Davies wished to select from a slab of rock showing weathered-out specimens of *Dictyoconoides* sp. from the Kirthars of Kotri in Sind, to serve as the type of this species in our collection, has been received back from him.

The specimens of *Ostrea* from the Tertiary beds of Baripada, in Mayurbhanj State, which are being described by Mr. F. E. Eames of the Burmah Oil Company and which were sent to him for making a selection for the purposes of illustration, have been received back.

At the suggestion of Prof. B. Sahni, specimens of ostracods collected by Mr. H. Crookshank from the Intertrappeans of the

[1] *Pal. Ind.*, N. S., Vol. V, Mem. No. 3, p. 28, (1916).

Central Provinces have been sent to Prof. J. H. Bonnema of Groningen, Holland, for examination and study.

Dr. L. F. Spath has in a recent publication ('Ammonites and Belemnites from Eastern Persia (Iran)', *Pal. Ind.*, N. S., Vol. XXII, Mem. No. 3) expressed the view that 'there has been a relative permanence of continents and oceans and that the Mesozoic deposits in what is generally called the Mediterranean or Tethyan area were formed during temporary transgressions of the seas just like the sediments of the epicontinental areas of northern Eurasia or anywhere else'. A similar view expressed by him in an earlier publication ('Jurassic and Cretaceous Ammonites and Belemnites from the Attock District', *Pal. Ind.*, N. S., Vol. XX, Mem. No. 4) was editorially commented upon in a footnote to page 37 and it was stated that this was the view of Dr. Spath and was not shared by the Geological Survey of India. Dr. Spath's opinions are based upon detailed studies of isolated faunas and his studies are confined to the Mesozoic history only of the Tethyan region. Some of the faunas studied by Dr. Spath are from areas close to the shore-line of the Tethyan sea. The idea of a gradually sinking ocean basin constituting the Tethys is founded upon a detailed study of the geological history of the region from the Cambrian upwards, and, as has already been pointed out, it is not necessary that the conditions for such deposition should have been bathyal throughout. Moreover, it may be noted that the idea of trangressions, as expressed by Dr. Spath, postulates the existence of unconformities, yet the Tethyan region records a continuous series of deposits without a break from the Permian to the Eocene.

Dr. M. R. Sahni reports the occurrence of three important fossil localities in the Southern Shan States. One of these occurs about a mile to the east of the village named Htangtabin (not shown on the map) located upon the site of the now deserted village of Me-so (21° 44′: 97° 0′). The fossils occur in a series of well-bedded limestones, shales or highly argillaceous limestones and sandstones with a W.N.W. dip, passing beneath the younger rocks further to the west. Among the fossils found are species of *Spirifer*, *Cystina*, *Platyceras*, *Fenestella*, *Chonetes*, *Atrypa reticularis*, *Leptæna rhomboidalis*, besides crinoid and blastoid stem plates and a rhynchonellid. The species so far identified occur both in the Silurian and Devonian formations. However, it was possible to separate these beds into two

divisions, a lower one with *Atrypa reticularis* and an upper division in which this well-known fossil is not found.

The same fauna occurs at another locality about a mile and a half further to the south-east of Me-so, near Taungtek, and indeed fossils can be picked up at several localities along the scarp between Me-so and Taungtek (21° 43′ : 97° 0′) rivalling in the degree of perfection the specimens obtainable from the classical locality of Padaukpin.

A third locality occurs in the upper division of the Plateau Limestone at Loi Pan (21° 44′ : 97° 17′), where a Permo-Carboniferous fauna in an excellent state of preservation was discovered. The fossil species occurring here belong to *Productus*, *Chonetes*, *Orthoceras*, *Pleurotomaria*, *Platyceras*, several species of anthozoan corals and a goniatite. Species of *Productus* are particularly common.

Mr. A. M. N. Ghosh reports that the Cretaceous beds of the Khasi Hills in the neighbourhood of Therriaghat (25° 11′ : 91° 46′) are highly fossiliferous. At the west bank of the Bhuban *nala* the lowest portion of the Cretaceous sandstone, just above its junction with the Sylhet trap, yielded an unusually large species of *Inoceramus*, measuring 24 inches by 10 inches, and other bivalves including *Protocardium* sp., two species of *Terebratula*, a well-preserved ammonite and several gastropods. In the neighbourhood of Nongiri (25° 12′ : 91° 48′), the upper reaches of the sandstones are occupied by softer beds teeming with *Baculites* sp., gastropods and bivalves; further west the sandstones carry abundant *Nautilus*. The sandstones at Mahadek (25° 13′ : 91° 45′) and at the Mawsmai Falls yielded several well-preserved specimens of *Stygmatopygus* sp. The impure earthy limestone and shales coming at the extreme top of the Cretaceous beds in the Khasi Hills yielded from Nongiri and Mahadek, a large number of casts of gastropods including *Xenophora*, *Strigatella*, *Cinula*, and *Murex*, several bivalve casts, a couple of well-preserved specimens of ? *Pachydiscus*, a giant *Nautilus* and a few badly preserved *Hemiaster*.

Mr. Ghosh found that the middle Nummulitic (Sylhet) Limestone at Therriaghat was rich in several forms of *Alveolina* and also records the occurrence of a marl band full of *Discocyclina* coming just above the upper Nummulitic Limestone bands at Therriaghat and Garu (25° 11′ : 91° 41′).

37. *Po series.*—The Po series as a whole has generally been classed as Middle Carboniferous, although the late Professor Zeiller had suggested that the flora of the 'Hayden collection' had Lower Carboniferous (Culm) affinities. Prof. Gothan of Berlin, after an examination of the specimens sent to him by the Director at Prof. B. Sahni's request, has confirmed Zeiller's opinion. At least the Thabo stage, in which most of the specimens were found, thus seems to belong to the Lower Carboniferous. This view has been expressed on independent grounds by Dr. Fox.

Plants.

Prof. B. Sahni of Lucknow University examined several collections of fossil plants sent to him by this Department.

Lower Gondwana.—In a paper on the Indian Glossopteris flora read before the 6th International Botanical Congress, Amsterdam, (September 1935), Prof. B. Sahni discussed, *inter alia*, the geological age of the Parsora beds, and the relations of the Glossopteris flora of India with the Palaeozoic floras of Siberia (Angara series) and of China (Gigantopteris flora). The association at Parsora of *Dicroidium* (*Thinnfeldia*) *hughesi* with *Næggerathiopsis hislopi*, a typical member of the Glossopteris flora, supports the opinion that these beds belong to the Permo-Triassic part of the scale and may, as Prof. Seward suggests, be as old as the Upper Permian. Their reference by Dr. Fox (1931) to the Upper Gondwanas (Jurassic) is quite inconsistent with the palæobotanical evidence[1].

Other questions relating to the Indian Glossopteris flora, which were discussed at Amsterdam, are summarised in a paper by Prof. B. Sahni published in the December 1935, number of '*Current Science*'.

Rajmahal series.—A report on recent additions to our knowledge of this classic flora, based chiefly upon petrifactions collected at Nipania, was presented before the 6th International Botanical Congress at Amsterdam. At the same Congress the significance of *Homoxylon rajmahalense* and other *Homoxyleæ* in the origin of angiosperms was discussed.

Ahmednagar sandstones.—In a collection of fossil plants made by Dr. A. M. Heron and Mr. P. N. Mukerjee from Himmatnagar (Ahmednagar) (73° 2′ : 23° 36′) in Idar State, specimens referable to *Weichselia reticulata* and to a new species of *Matonidium* have been recognised by Prof. B. Sahni. *Weichselia reticulata* is a fern eminently characteristic of the Wealden period. It has been found in Europe, Northern Africa, Syria, America and the Far East.

[1] *Current Science*, Vol. IV, No. 6, pp. 386-7, (Dec. 1935).

The genus *Matonidium* ranges from the Jurassic to the Cretaceous, most of the records being Lower Cretaceous. The fertile pinnæ of the Indian species closely resemble those of *M. gœpperti*, which is known from the Inferior Oolite and Wealden of England and other parts of Europe.

The discovery of these two ferns in India is interesting, as it extends the geographical range of these well characterised genera. Apart from these two forms there are fragments of other fern-like plants not yet specifically identified. According to Prof. Sahni the available evidence, although not quite conclusive, strongly suggests a Wealden age for the Ahmednagar sandstones.

Mr. C. S. Middlemiss[1] discovered dubious plant remains here.

Deccan Intertrappean Flora.—This flora is being described in detail in collaboration with Mr. H. S. Rao. Meanwhile the idea that the beds are of Tertiary age seems to find support in some further palæobotanical evidence (*see* S. R. Narayan Rao and K. S. Rao, '*Current Science*', November 1935, p. 321), although we must await the description of the newly discovered plants before this evidence can be accepted. Some specimens of crustacea, supposed to belong to *Cypris*, have been sent at Prof. Sahni's request to Prof. H. Bonnema, of Groningen, for his opinion as to their affinities, and are expected to throw light on the age of these beds.

At the suggestion of Prof. B. Sahni of the Lucknow University, the Comité Geologique, Leningrad, was requested to send to this Department a representative collection of fossil plants of the Angara series in exchange for a similar set of Indian Gondwana plants. A good collection of plant fossils has been received from the Central Geological and Prospecting Tschernyschew Museum, Leningrad, and these have been exhibited in the Foreign Collection section in the Indian Museum.

At the request of Mr. Paterson of the De Terra expedition, twenty-eight specimens of palæoliths collected by Mr. D. N. Wadia from the Potwar have been sent to him on loan.

Donations.

38. During the year under review, presentations of fossils were made to the following institutions :—

Geological Survey of the Dutch East Indies, Bandoeng, Java.—Specimens of gastropod fossils from the Mekran beds and the Pegus of Burma. (By exchange.)

[1] *Mem. Geol Surv. Ind.*, XLIV, Pt. 1, p. 141, (1921).

Prince of Wales Medical College, Patna.—A collection of plant fossils.

University College, Rangoon.—A representative collection of invertebrate fossils from Burma, as also a specimen of Fenestella Shale, to the Department of Geography and Geology and a set of plant fossils to the Biology Department.

C. M. S. High School, Bhagalpur.—About thirty fossils consisting of vertebrates, invertebrates and plants for educational purposes.

Calcutta Blind School, Behala, Calcutta.—A collection of fossils for educational purposes.

Stanford University, Department of Geology, California.—A collection of Triassic ammonites and other specimens. (By exchange.)

State Microscopical Society of Illinois, Chicago.—Specimens of foraminifera and a few specimens of fossiliferous limestones.

All India Institute of Hygiene and Public Health, Calcutta.—A few coral specimens for the museum.

39. In addition to those previously mentioned, donations of fossils or casts of fossils were received either by presentation or by exchange from the following persons or institutions :—

Geological Survey of the Dutch East Indies, Bandoeng, Java.—Skull of *Homo* (*Javanthropus*) *soloensis* (cast) and some other fossil bones. (By exchange.)

Prof. Gayle Scott.—Danian fossils from Midway, Texas. (By exchange.)

Mr. Ing. Hugo Smela, 31, Stefanikora, Prague XVI, Czechoslovakia.—Some well-preserved specimens of trilobites, *e.g.*, *Ellipsocephalus* sp., from the Middle Cambrian beds of Jince, Central Bohemia, Czechoslovakia. (By presentation.)

Dr. C. A. Matley.—A collection of specimens of *Estheria mangliensis* and of *Unio*, *Physa*, etc., made by him in 1932-33 in the Central Provinces. (By presentation.)

Dr. B. Prashad, Director, Zoological Survey of India, Calcutta.—A fragmentary bone, part of a scaral vertebra probably of the ox, from Sitamarhi. (By presentation.)

Mr. *C. Stabler, Assistant Engineer, Bengal Nagpur Railway, Umaria.*—Fossil specimens of *Paludina* and *Bullinus prinsepii* in boulders from Umaria. (By presentation.)

Stanford University, Department of Geology, California.—A set of Triassic ammonites and other specimens from Idaho, Nevada and California. (By exchange.)

Jardin Zoologique de Sfax (Tunisie).—A set of Quaternary shells from Tunis in exchange for some copies of *Palæontologia Indica.*

EARTHQUAKES.

The Quetta earthquake of 31st May, 1935.

40. After a lapse of only sixteen and a half months, India has again been visited by a disastrous earthquake, this time in the vicinity of Quetta in Baluchistan. Though it is not yet possible to estimate the number of lives lost, it is likely to have been not less than 25,000, thus rendering this earthquake the most disastrous that has visited India within historic times. In addition to the lives lost, very great material damage was sustained at Quetta, Mastung, and a large number of villages. At Quetta the city was almost completely demolished, while the railway area and the R. A. F. lines were very badly damaged.

Upon receipt of the news of the disaster, Mr. W. D. West, who had investigated the Baluchistan earthquakes of 1931, was deputed to examine the devastated area, and he arrived at Quetta on June 10th. A preliminary geological report was written by Mr. West for the use of the Army Department of the Government of India and for the Baluchistan Government, which has been published in Part 2 of Volume LXIX of these *Records.*

The earthquake occurred at approximately 3·03 hours (Indian Standard Time) on May 31st, 1935. It seems to have lasted about half a minute, and was not preceded by any noticeable foreshocks within the epicentral tract. The latter was an area about 68 miles long and 16 miles wide, extending from the north-west side of Quetta, through Mastung, to halfway between Mastung and Kalat. Within this area, a shock of intensity 9 to 10 on the Rossi Forel scale was experienced, and a large proportion of the buildings were laid in ruins. Although the shock was of considerable intensity at the epicentre, the total area over which it was felt was little more than 100,000 square miles. The high mortality was largely due to the poor manner in which buildings in Baluchistan are constructed, to the narrowness of the streets in Quetta city

and in most of the villages, and to the fact that the earthquake occurred during the night.

An interesting feature of the earthquake was the manner in which certain buildings, recently constructed on earthquake-proof lines by the North Western Railway, withstood the shock admirably.

Natural phenomena associated with the earthquake included heavy falls of rock on the more precipitous limestone mountains, notably on Chiltan, a line of fissuring in the alluvium extending on and off for about 65 miles along the centre of the epicentral tract and the eruption of a small mud volcano some 12 miles south of Kalat.

As regards the cause of the earthquake, although the epicentre was aligned parallel to the strike of the area, there appeared to have been no movement along any visible fault, and the exact origin of the earthquake must remain in doubt.

Bengal and Assam.

41. From north-eastern India, a number of minor earthquake shocks were recorded during the year. These included a fairly sharp quake that occurred at about 5·30 A.M. on the morning of 21st March, and another at about 10-45 P.M. on 23rd April. Both were felt over a large portion of Assam and Bengal, the former shock being experienced in Calcutta. No damage to buildings was reported.

ECONOMIC ENQUIRIES.

Bauxite.

Bastar State, Central Provinces.

42. High level laterite caps the Bailadiḷa ridge. Although Mr. Crookshank saw no undoubted bauxite he found pisolitic laterite and lithomarge similar to that which is usually associated with bauxite, and he thinks that bauxite very probably also occurs.

Kaira district, Bombay.

43. Mr. P. N. Mukerjee reports the occurrence of a rich deposit of bauxite near Taibpur village (73° 5′ : 23° 3′) in the Kapadvanj *taluka* of the Kaira district, Bombay. The deposit was formerly worked by Messrs. Killick, Nixon & Co. of Bombay, who have now ceased work.

Bismuth.

44. An occurrence of metallic bismuth as a rounded pebble from the washings of the Kyaukpyathat mines in the Mogok area was noted by Dr. Iyer. The mineral on examination in the laboratory proved to have a specific gravity of 9·8.

Mogok area, Burma.

Building Materials.

45. Dr. A. K. Dey reports the occurrence of small veins of crystalline limestone at Kultanr (22° 59' : 86° 34'), Tamakhun (22° 59' : 86° 36'), on the hill north-west of Kumari (22° 58' : 86° 38'), at Gobindpur (22° 58' : 86° 39'), near Mirgichanda (22° 58' : 86° 41'), and on the bank of the Kumari *nadi* south-east of Kantagora (22° 58' : 86° 42'). All the veins occur close to a great fault. The crystalline limestone at Tamakhun has already been recorded by Ball.[1]

Manbhum district, Bihar and Orissa.

46. At the request of the Government of Bombay, Dr. P. K. Ghosh examined the Eocene limestone deposit at Tarkeshwar (21° 22' : 73° 6'), Mandvi *taluk*, Surat district, Bombay, 45 miles from Surat. The limestone is yellow or brown in colour, and varies in texture from slightly cavernous and earthy to dense and compact, with abundant nummulites. An analysis made in the Geological Survey of India laboratory by Mr. P. C. Roy gave:—

Surat district, Bombay.

	Per cent.
SiO_2	3·00
Al_2O_3 / Fe_2O_3	4·72
CaO	49·23
MgO	0·43
Loss on ignition (CO_2, H_2O, *etc.*)	40·25
TOTAL	97·63

This shows that the percentages of silica and magnesia are less than 10 and 4 respectively, the maxima allowable in the manufacture of Portland cement.

[1] *Mem. Geol. Surv. Ind.*, XVIII, pp. 17, 49, (1881).

47. Mr. P. N. Mukerjee reports the occurrence of Lameta limestones south of Gabat village (73° 23′ : 23° 15′ 30″) in the Idar State. The rock is locally used as a building stone and is also burnt as a source of lime.

Mahi Kantha Agency, Bombay Presidency.

48. Mr. P. N. Mukerjee also reports the occurrence of gritty sandstones (Ahmednagar sandstones) near Himmatnagar (73° 2′ : 23° 36′) in the Idar State, and Ilol (72° 56′ : 23° 39′) in the Ilol State in the Mahi Kantha Agency of Bombay. The rock is extensively quarried in both places and used as building material.

Mahi Kantha Agency, Bombay Presidency.

Clays.

49. In previous surveys and again during 1934-35, Dr. C. S. Fox has met with beds of kaolin or an underlying kaolinised gneiss below the coal-bearing sandstones at the base of the Eocene in the Garo Hills. The occurrence is so general that Dr. Fox had already been forced to the conclusion two years ago that this horizon of kaolinised gneiss corresponds with the main laterite-forming period of the Indian peninsula in early Eocene times. This means that the Assam plateau must have been largely a land area at the close of the Mesozoic, and it also means that potential reserves of kaolin are widespread in the southern parts of Assam. Dr. Fox has found kaolin in numerous places in the Garo Hills, from the valleys of the Kalu up to Tura and again in the Simsang about Siju. During the past season he noted occurrences near Dobu (25° 33′ : 90° 43′), below the coal measures of the Darang field near Boldakgithim (25° 27′ : 90° 40′) and around the inspection bungalow of Rongrenggiri (25° 33′ : 90° 34′). These are, of course, all very inaccessible at present pp. 82-84.

Garo Hills, Assam.

50. Dr. A. K. Dey reports the occurrence of white clay near Dandudih (22° 59′ : 86° 33′), Tamakhun (22° 59′ : 86° 36′), and south of Balrampur (22° 59′ : 86° 38′), close to the great fault of south Manbhum. The material is not fine and it would have to be washed and concentrated before being placed on the market. The deposits near Balrampur are now worked by the Manbhum Mines Co.

Manbhum district, Bihar and Orissa.

Coal.

Garo Hills coalfields, Assam.

51. During the season 1934-35, Dr. C. S. Fox was able to visit the so-called Daranggiri and Rongrenggiri coalfields in the Upper Simsang valley in the Garo Hills. Both these areas of Lower Eocene strata occur within the gneissic rocks north of the Tura range and were evidently brought into this position by block faulting of late Miocene or later age. Both fields were formerly regarded as Cretaceous, but Dr. Fox and Mr. A. M. N. Ghosh have given reasons for believing that the Cherra sandstones are of Lower Eocene age, and consequently the age of all those beds which were correlated with the Cherra sandstones is now changed to suit. Dr. Fox was impressed by the coal seen in the Rongmuthupathal section (25° 27′ : 90° 42′), where in the stream cliff, just above the village, a six-foot seam of excellent quality coal is exposed. This outcrop has been known for over 70 years, but owing to the inaccessibility of the place, there has been no production. Dr. Fox agrees with the opinion expressed many years ago by La Touche that a large supply of coal is available in this Darang coalfield (there is no village of the name of Daranggiri and no such name occurs on the old maps). The dips are gently to the east and the measures have been denuded to the west where the gneisses appear from below these coal-bearing Eocene sandstones.

Further to the west, a great north-south fault drops in the Eocene strata to the west, but these beds are somewhat younger, with Eocene marine fossils. The coal measures outcrop higher up the Simsang, but the coal seams so far examined are too thin for serious consideration. The western part is known as the Rongrenggiri coalfield, but the strata extend from the above-mentioned fault, near Rongbinggiri (25° 29′ : 90° 37′), to beyond Dolwarigiri. The beds are gently inclined eastward but the coal horizon is not seen east of Rongrenggiri, until lifted by the Rongbinggiri fault to continue as the Darang coalfield further east. It is probable that the coal is of workable thickness towards the eastern part of the Rongrenggiri field, but it will be 300 to 400 feet at least beneath the younger marine strata. It is also certain that the Darang area would in any case be the more attractive from the better seam actually exposed and the more convenient location of the area.

Subsidence, Jharia coalfield.

52. At the end of December 1935, Dr. C. S. Fox, at the request of the Chief Inspector of Mines, examined the conditions which had arisen owing to underground fires in seams XI and XII to the west of the Kari Jor, a stream which flows through the Jharia coalfield.

These seams have been extensively worked on both sides of the Kari Jor and in consequence considerable subsidence has taken place, though so far not in the bed of the stream itself.

It is, however, feared that subsidence may result, due to fire in these seams on the western side having travelled eastwards and spread to below the Kari Jor. Collapse of the stream bed would entail the grave danger of flood-water from the stream entering the workings and flooding collieries to the dip.

The coal was first set alight in old coal quarries to the west, where these seams were opened up. These quarries formed a convenient dump for soft coke rubbish, and some of this, being still hot when tipped in, set fire to the coal in the quarry, and so spread down the seam along galleries which had been driven from the quarries.

Efforts are now being made to damp out the fires and pack the workings by sluicing sandy clay and water down bore-holes into the burning seams on the west side, and if these are successful, subsidence of the stream bed and consequent flooding will be averted.

In the event of their non-success, three schemes had been suggested for dealing with the flood-water of the Kari Jor, (i) to take the river discharge over the section of the bed where subsidence was to be expected, by a suspension bridge carrying pipes of large diameter, or a suspended concrete aqueduct; (ii) to pass the flood-water below the threatened workings in an inverted siphon; (iii) by making a diversion of the Kari Jor on the eastern bank.

Dr. Fox's objection to the first scheme is that the foundations of at least one of the piers of the suspension bridge would be in jeopardy from the subsidence, and to the second scheme that the siphon would immediately silt up in a flood, as the water in it would become 'dead', and the water coming down the stream could hardly set it in motion. The third scheme he considered the most promising, but the diversion itself would be subject to the same risk of subsidence as the main bed.

The Kari Jor, though almost dry in the dry season, is supposed to carry a flood discharge computed at five million gallons per

minute, with a depth of 7 feet across the bed, which is nearly 150 feet wide in places. The river has a straight course over a relatively smooth rocky bed over the danger belt and for some distance above and below it.

Dr. Fox recommends that active flushing in of sand and water should be energetically pursued to check the fire, and that the existing levee on the west side be increased in height and width by accumulating a large amount of sand and debris on it, to maintain it if collapse begins. Should subsidence begin in the rocky bed of the river, he believes that it will be effectively countered by choking the subsided portion with rock, stones and mud, with the object of keeping the channel of the Kari Jor as straight and smooth as possible, to avoid any checking of the current. If this is maintained when the floods come down, Dr. Fox thinks that even during spates any large holes can be choked by debris fed in from upstream by a gantry turned to overhang the stream just above the danger zone, but a large amount of material should be accumulated in readiness.

Copper-ore.

Mogok area, Burma.

53. Near the 5th milestone on the Thabeitkyin-Mogok road, a vein of copper-ore reported to contain gold occurs in the limestone. Some years ago a pit was sunk and samples taken by the Ruby Mines Company, Ltd. The venture was not, however, proceeded with.

Bankura district, Bengal, and Manbhum district, Bihar and Orissa.

54. In the course of his work in the Bankura and Manbhum districts, Dr. A. K. Dey found traces of copper-ore in the form of chalcopyrite and malachite in the phyllite in the stream bed south of Sarengarh (22° 57′ : 86° 44′) in Bankura, south-west of Kantagora (22° 58′ : 86° 42′) in Manbhum, near Nilgiri (22° 57′ : 86° 43′) and in the dumps from a prospecting trench along a fault-rock north of Narainpur (22° 58′ : 86° 44′) in the Bankura district.

Corundum.

Mangalore district, Madras.

55. Dr. P. K. Ghosh was deputed to report on the corundum deposits at Uppinangadi (12° 50′ : 75° 16′) and the neighbouring villages of Hirebandadi and Bajathur in the Puttur *tahsil*, Mangalore district, Madras Presidency. The corundum occurs as a detrital

deposit in the alluvium in the valleys and beds of the tributaries of the Netravati river. The amount obtained by panning, however, is scanty and the prospects of obtaining commercial quantities of corundum are poor.

Engineering and Allied Questions.

Saranda tunnel, Bengal-Nagpur Railway.

56. Following a request by the authorities of the Bengal-Nagpur Railway, Dr. C. S. Fox, in July 1935, reported on the advisability of lining the lower, more recently constructed tunnel (one of the 'Saranda' tunnels) situated between miles 218 and 219 on the Main Line of the Bengal-Nagpur Railway, that is, about 25 miles along the line south-west from Chakradharpur (22° 41′ : 85° 38′). The tunnel in question is about 3,500 feet long and is aligned somewhat to the west of, and about 25 feet lower than an older tunnel on the Up line for Nagpur. It was opened about six years ago. During the past five years, trouble has been experienced at intervals owing to relatively minor rock-falls from the roof and sides of the tunnel. As a result, several sections of the tunnel have been lined with brickwork. The work of lining the whole length of the tunnel was contemplated at the time of Dr. Fox's visit.

He observes that the rocks encountered in the tunnels consist mainly of phyllites of the Iron-ore series,[1] some being carbonaceous, others calcareous, whilst pyrite was commonly included. The rocks have a pronounced slaty cleavage running mainly between W.N.W. and W.S.W. to E.N.E. and E.S.E., whilst other joint planes also occur, so that in places the rock is badly shattered.

Dr. Fox considered, however, that in general the rock appeared to be relatively sound and that serious falls are unlikely provided the tunnel lining is completed as at present sanctioned, though in certain portions where the rock is decomposed, a stronger lining may be necessary.

In addition, Dr. Fox noted the possible corroding effect of acid solutions resulting from the oxidation of the iron pyrites that is included in the phyllites. He suggested that this factor might be largely eliminated by taking steps to minimise percolation into the tunnel. With this object in view, he suggested (*a*) that any water entering the old (higher) tunnel be drained out of that tunnel and

[1] H. C. Jones, *Mem. Geol. Surv. Ind.*, LXIII, Pt. 2, p. 193, (1934).

thus be prevented from percolating down through the strata towards the new tunnel, and (*b*) that the surface above the tunnel and in its vicinity be efficiently drained by artificial channels.

Khojak tunnel, Baluchistan.

57. At the request of the Chief Commissioner of Railways, Mr. W. D. West included in his preliminary report on the Quetta earthquake a section discussing the safety of the Khojak tunnel, near Chaman, in the event of an earthquake in that region. The Khojak tunnel is nearly two and a half miles long, and its western end is less than a mile and a half from a fault which has been the focus of several severe earthquakes in the past, notably the Chaman earthquake of 1892.

It has long been thought that the intensity of the long waves diminishes in depth, but until recently little accurate research has been carried out in the matter. Recent investigations in Japan, however, have shown conclusively that the amplitude of the wave motion decreases with depth, being shown in one experiment to decrease at a depth of 500 feet to about ·37 of what it was at the surface. This fact probably accounts for the manner in which deep tunnels so frequently escape severe damage during an earthquake. In the Quetta earthquake, the Nishpur tunnel, situated within the tract of country most severely disturbed, remained undamaged.

As regards the Khojak tunnel, Mr. West is of opinion that, as it is lined throughout with brick or stone masonry set in a cement mortar, and that as it is more than 200 feet below the surface of the ground for over 9,500 feet of its total length of 14,000 feet, further reinforcement does not seem to be necessary. He recommends, however, that the engineers of the North-Western Railway should examine the first 1,000 feet of the tunnel at each end to ascertain its condition, and to strengthen it if they think it necessary.

Gem-stones.

Diamond.

Anantapur district, Madras.

58. About the beginning of August 1935, a diamond said to be an inch long, half an inch wide and a quarter of an inch thick, of a pink colour tinged with blue, is reported to have been picked up by a cultivator of Konganapalli village (15° 11′ : 77° 33′), Anantapur district, while ploughing, and was sold in Bombay for Rs. 6,600.

Konganapalli is north-east of and close to Patakottacheru Railway Station near Gooty. It lies 15 miles north-east of Wajra Karur, a well-known diamond locality.

Ruby and Sapphire.

Kyetsaungtaung and Nyaungbintha, Burma.

59. Dr. Iyer reports that in the area west of the Kin Chaung, although crystalline limestone and granite contacts occur, precious stones are only occasionally found. A good ruby is reported to have been found near Kyetsaungtaung (22° 50′ : 96° 2′), south-west of Wabyudaung, whilst illicit mining is said to yield an occasional stone near Kyaukkyi (22° 59′ : 96° 9′). Recently in the stream north of Nyaungbintha (22° 53′ : 96° 10′) gem mining was prevalent, and a few good stones are reported to have been obtained.

Gold.

Paunglaung valley, Upper Burma.

60. Gold has been known by the local inhabitants to occur in the Paunglaung valley from historical times and just before the annexation of Upper Burma it was fairly extensively worked by Chinese, probably contemporaneously with Chinese lead-silver activities at Bawdwin in the Northern Shan States and at Mawson in the Southern Shan States. The method employed for the extraction of gold was to a large degree similar to that used for the winning of lead-silver ores in other places. It consisted of sinking a large number of closely spaced pits in selected areas. The floor of the valley in sheets 93D/11-15 and D/12-16, roughly from latitude 20° 16′ southwards, is, according to Mr. Sondhi, covered by a thick series of coarse pebble and silt beds deposited by the Paunglaung stream, probably in Pleistocene times when it was much larger than at present. The coarser nature of the more basal of these deposits points to the torrential nature of the river's early days. After reaching its base level of erosion it must, in sub-Recent to Recent times, have been rejuvenated, as it has cut through these deposits and begun to erode the solid rocky formations below and only the remains of the former more extensive pebble and silt beds now persist. These occur in stretches on the concave sides of the larger bends of the stream. As the valley of the Paunglaung *chaung* is comparatively narrow the width of these raised gravel deposits is

restricted and although the highest levels reached by them may vary from 30 to 50 feet, the more general level is from 15 to 20 feet above the present level of the stream. At the base of these deposits, immediately overlying the upturned edges of the sedimentary series of doubtful age, there is a fairly constant pebble bed of about three feet in thickness, which appears to carry the main values, although the higher beds of this deposit are auriferous to some extent. The Chinese, in sinking shafts, thousands of which exist in the Paunglaung valley, seem always to have had this basal bed as their objective.

Besides in this pebble bed, gold is present in small quantities in the bed of the stream itself and also in the beds of many of the smaller tributary streams. For the most part it occurs as fine dust or flakes, but nuggets larger than a pin-head are, rarely, found. There are a few small villages in the valley and some of the inhabitants practise gold-washing during certain months of the year. It does not, however, bring them such an attractive return as to induce them to make it a whole-time occupation.

All the localities visited by Mr. Sondhi lie either in the above-mentioned gravel or in the stream beds, over a wide area and under so diverse conditions that it is difficult to come to a definite conclusion as to the origin of the gold. In the Paunglaung valley small exposures of diorite were met in two places, one near the northern end of sheet 93D/12-16 and the other near Nanpa in the south-west corner of sheet 93D/11-15, and their existence at one or two places near Taloktwin is suspected. If the origin of the gold is associated with these intrusions, as happens in the case of similar rocks at Mwe-daw to the north in sheet 93 D/10-14, the existence of the metal in the tributary streams away from the main valley is difficult to explain, unless a widespread network of intrusions, of which there is no visible sign, is presumed. The igneous belt on the west of the sedimentaries, represented by granite and porphyry, cannot be the source of the gold, as the known localities become less and less in that direction and practically end before the granite outcrops are reached. It is Mr. Sondhi's opinion therefore that the principal source of gold in the Paunglaung valley is to be sought in the sedimentary rock formation to which the drainage of the stream is mainly confined in this area. It must be noted however that this opinion is based on rapid traverses mostly along the strike of the rocks, and may have to be modified when a larger area is

systematically mapped and when geological conditions are better known than at present. The fact remains that the main gold values lie in the basal pebble bed of the raised river deposits that cover the floor of the Paunglaung valley.

Near the Thabeitkyin-Mogok road, Burma.

61. Gold is said to occur south of the 8th milestone on the Thabeitkyin-Mogok road, where the debris of a broken quartz reef was noted by Dr. Iyer. The soil of the vicinity is generally collected by the villagers after the rains and small quantities of gold are obtained by washing.

Bastar State, Central Provinces.

62. Gold occurs in river gravels along all the streams south of Malkanagiri, in the Malengar river, and in the tributary of the Sankani running south-east from near Masenar. The source of the gold is uncertain. It can be recovered economically only by the local gold washers.

Graphite.

Mogok area, Burma.

63. Graphite occurs distributed throughout the Mogok area in the crystalline limestones, calciphyres, garnet-gneisses and khondalites. South-west of Wabyudaung (22° 52′ : 96° 9′), large pockets of graphite have been found in the gneiss and pegmatite. Attempts were made to work these deposits some years ago, but were soon abandoned. Small pebbles of graphite debris occur on the surface of the ground and in the streams in the vicinity of the occurrence.

East Godavery district, Madras.

64. Dr. P. K. Ghosh was deputed to visit the old graphite mines in Rekapalli *firka*, Bhadrachalam *taluk*, East Godavery district, Madras Presidency.

He reports that there are two extinct graphite mines at the south-east flank of Puli Konda (17° 33′ : 81° 26′) and the northern flank of Racha Konda (17° 32′ : 81° 25′) respectively, and also several shallow pits. The graphite has also been found as a detrital deposit in a pocket 3 feet by 9 inches by 1½ inches in the alluvium in the southern flank of Sutru Konda, 1½ miles to the west of Puli Konda. The mines were operated by Messrs. Binny and Co., Madras, through their agents the Godavery Coal Co., Ltd., Cocanada, but no details of the volume of the business are available.

The country-rock is formed of the khondalite series, tilted vertically and striking N.N.E.-S.S.W. and injected by granite and pegmatite veins. From his examination of the old mines, Dr Ghosh concluded that the workable graphite deposit occurred as definite N.N.E.-S.S.W. bands, one to two feet in width and 40-50 feet in length, in the khondalite series. He believes that these bands represent original intercalates of carbonaceous impurities since altered by metamorphism into graphite.

The old mines are practically exhausted but there is a likelihood of workable amounts of graphite being present in Sutru Konda and its neighbourhood, since large bladed graphite crystals have been found as a detrital product in a pocket in the alluvium in this locality.

Gypsum.

Dehra Dun district, Tehri Garhwal State, United Provinces.

65. Occurrences of gypsum in the neighbourhood of Rajpur and Jharipani, between Mussoorie and Dehra Dun, have been known for over a century[1]. Mr. J. B. Auden states that the gypsum is located in the Lower and Upper Krol limestone. He has found another occurrence of gypsum on the north bank of the Song river, 600 yards W. N. W. of Sera (sheet 53 J/3: 30° 18′ : 78° 14′) which is just within Tehri Garhwal State. The gypsum occurs there as lenticles replacing the dark magnesian limestones of the Krol D stage. The lenticles are arranged parallel to the bedding and average about one foot in thickness and three feet in length. The gypsum is fairly pure, though it contains occasional nodules of unreplaced limestone. The associated Krol shales are covered with an efflorescence of magnesium sulphate. On the south bank of the river, opposite Sera village, is found a sulphur spring which doubtless has some genetic connection with the gypsum on the north bank.

Iron-ore.

66. Deposits of iron-ore were noted by Mr. Crookshank both on the east and the west side of the Bailadila ridge. Average specimens taken from these contained 68·79 per cent. of iron.

[1] Bibliog. Ind. Geol. and Phys. Geog., Annotated Index of Minerals of Economic Value, pp. 230, 231, (1918).

Bastar State, Central Provinces.

No estimate of the quantity of ore present is available as the mapping of the area is not yet complete, but it can be said with certainty that the deposits are both rich enough and large enough for exploitation. Isolation alone prevents their utilisation.

Mayurbhanj State and Dhalbhum, Bihar and Orissa.

Deposits of vanadium-bearing titaniferous iron-ores from southern Dhalbhum and northern Mayurbhanj have recently been investigated. The V_2O_3 content of these ores, varying from 0·6 to 6·0 per cent., is very capriciously distributed, and depends mainly on the presence of a new mineral variety, vanado-magnetite, which occurs in them. The largest deposit is near Kumharoubi (22° 18′ : 86° 19′), in Mayurbhanj State, where there is at least one million tons of debris scattered over the surface of the hill slopes. Until very careful close sampling is done, it is not possible to say what grade of V_2O_3 could be obtained from here. The country extending south towards the Simlipal jungle has also not been surveyed, but the indications are that these deposits are likely to be found to the south, as the basic igneous rocks with which they are associated continue in that direction. It may be remarked that this area deserves close prospecting and thorough sampling before discarding it as a likely source of vanadium. It should be understood, furthermore, that as this is the only high grade (probably) type of vanadium-bearing iron-ore known, a suitable method of extraction would have to be developed. The solubility of the vanado-magnetite suggests that a wet process may be a likely line of investigation.

Lead-ore.

Namhu, Southern Shan States.

67. Galena is reported by Dr. M. R. Sahni to occur about five miles west of Namhu in the bed of a small hill stream known as Mokso-nga-pan (21° 46′ : 96° 41′) in the Southern Shan States in Sheet 93 C/9. At the time of Dr. Sahni's visit the entire hill-side had slipped and choked up the dry bed of the stream and no specimens of ore could be found. Blocks of slickensided rock are common and in Dr. Sahni's opinion there is no doubt that a fault crosses the stream-bed here and that the occurrence of ore is connected with it.

Near the Thabeitkyin-Mogok road, Burma.

68. Near the 12th milestone on the Thabeitkyin-Mogok road, Dr. Iyer reports that a vein of quartz containing galena cuts a ridge formed of crystalline limestone and calc-gneiss, and that prospecting has been carried out on this vein within comparatively recent times, as may be seen from the pits sunk in it. The galena occurs as streaks in the quartz and is reputed to contain a little silver.

Bankura district, Bengal.

69. Dr. A. K. Dey noticed a few crystals of galena in a small quartz vein occurring in a paddy-field about half a mile W. N. W. of Kama (22° 53′ : 86° 44′). No exploratory work has been done on the deposit, which appears to be more of academic interest than commercial value.

Lepidolite.

Bastar State, Central Provinces.

70. A visit was made by Mr. Crookshank to the area where lepidolite had been found during the previous field season. Two deposits were mapped. The one occurs about 400 yards south of Mundval (18° 39′ : 81° 56′), and extends east-west about 300 yards. A prolongation of this deposit was noted along the same strike about 400 yards further west.

A richer looking occurrence was noted on the face of the hill about 600 yards south by west of Mundval. The pegmatite in which the lepidolite occurs is about 30 feet wide by about 70 yards in length. The lepidolite is confined to 15 feet in the centre of the pegmatite. It forms large boulders separated by a network of veins and minor boulders. All these are embedded in brittle white quartzite.

A shallow trench was cut across the pegmatite in order to ascertain the percentage of lepidolite present. It was estimated that if the whole lepidolite-bearing part of the pegmatite was extracted, about 15 tons of lepidolite would be obtained for every foot in depth of pegmatite extracted. For this output about 90 tons of useless quartz would have to be taken out also.

Petroleum.

71. Charge of the office of the Resident Geologist, Yenangyaung was held by Mr. E. J. Bradshaw until his departure on leave

on the 21st April and after his return from leave on the 9th December. Charge of the office was held by Mr. E. L. G. Clegg during Mr. Bradshaw's absence on leave. The Resident Geologist was consulted on technical matters arising out of the administration of the oilfields and on problems relating to leasing and development. Routine work included advice on the drilling and abandonment of wells and the storage and measurement of oil.

Resident Geologist Yenangyaung, Burma.

During the year the Resident Geologist was consulted on technical matters during the preparation of draft Rules under the Burma Oilfields Act, 1918, as amended by Burma Act No. VII of 1933. The draft rules, whose purpose is to give effect to the objects of the Burma Oilfields (Amendment) Act, 1933, were completed during the year and have since been published for opinion and criticism.

Draft Rules under the Burma Oilfields Act, 1918.

Natural Gas.

72. In consequence of a request made by the Government of Bombay in the Revenue Department, Dr. P. K. Ghosh revisited in August and September, 1935, the fourth bore-hole near Sonaria tank, about $1\frac{1}{4}$ miles to the west of Gogha in the Ahmedabad district[1].

Gogha, Ahmedabad district, Bombay.

As a result of the visit, Dr. Ghosh recommended that the boring operations commenced by a private firm in February, 1934, should be discontinued, as the locality chosen for boring was situated almost at the bottom of a syncline and was fairly close to the third bore-hole, reported on by Dr. Ghosh in 1932, which has been discharging an uninterrupted flow of gas since 1921. Moreover the locality in question was not one of the six sites which, on structural grounds, Dr. Ghosh had selected in 1932 as suitable for exploration.

According to Dr. Ghosh, the data obtained from the bore-hole indicated that there are two layers of gas-sand at 841-845 feet and 957-960 feet respectively, the latter being perhaps a continuation of the gas-bearing stratum met with at the third bore-hole at Gogha. As is to be expected, the amount of gas emitted is scanty; it is issuing as small bubbles with a fairly copious supply of water. The evidence is not clear as to whether the gas-sands are independent

[1] See 'General Report for 1933' *Rec. Geol. Surv. Ind.*, LXVIII, pp. 42-44, (1934).

of water; the simultaneous issue of gas and water may be due to the seepage of water along the sides of the bore-hole pipes from higher horizons. It is essential that the gas horizon should be kept perfectly watertight. Hence, in future operations, all the water-sands should be cemented off with the progress of the bore-hole.

Unsatisfactory as the Sonaria bore-hole is from the commercial point of view, it has at least served to confirm Dr. Ghosh's views concerning the patchy distribution of gas-sands in this area (at Gogha only one gas-sand was found, while at Sonaria tank there are two), and the extension, although in a very attenuated form, of the Gogha gas-field at least up to the Sonaria tank site.

The records of the bore-hole have not added substantially to our knowledge of the gas-bearing potentialities of the area. Dr. Ghosh does not think it worth while putting down bore-holes in the Gogha anticline as the gas-content of the anticline must be much reduced by now.

As regards the other anticlines, *viz.*, Bhumbli, Rampur, Ratanpur Nava, Kuda, Avania and Akvada, it yet remains to be proved that they contain gas in commercial quantities, although such a possibility certainly exists. Accordingly, if it be decided to pursue the investigation further, Dr. Ghosh recommends the sinking of bore-holes near the crests of these anticlines in the first instance. From the results obtained from these bore-holes, a better idea will be formed of the gas-content of the Tertiary belt in the north-eastern part of Kathiawar.

Ankleshwar taluk, Broach and Panch Mahals district.

In the bore-hole situated at Hajad in the Ankleshwar *taluk*, Broach and Panch Mahals district, Bombay, on the east coast of the Gulf of Cambay, Eocene Nummulitic limestone was met with at a depth of 30 feet, and boring was continued in the Nummulitics to a depth of 180 feet, when further work was discontinued as a result of Dr. Ghosh's advice. Dr. Ghosh considered it advisable for work to be restricted to Gaj sediments in the first instance, as the gas on both sides of the Gulf has so far been obtained from sediments of this age.

Salt.

73. During the Pujah holidays in October, Mr. E. R. Gee visited the Salt Range, Punjab, in order to advise the Northern India

Salt Revenue Department on certain points in connection with the exploitation of the rock-salt resources of that area.

Mayo Mine, Khewra, Punjab.

In the Mayo Mine, Khewra (32° 38′ : 73° 1′) he observed that, in the south-eastern part of the mine, the new 23 incline has proved the Middle Pharwala seam and that cross-cuts were being driven in that seam to the east and west. He advised the driving of an exploratory drift towards the south from this cross-cut near chamber 25 in order to prove the thickness of the seam. In the Pharwala development tunnel he noted that the recent extension had passed through the Sujowal seam into the Buggy seam, though the division between the two seams is here less definite and the seams, so far proved, are of poorer quality than in the more western workings.

Kalabagh, Punjab.

At Kalabagh, (32° 58′: 71° 33′), Mr. Gee examined the exploratory drifts that are being driven near Kalabagh town. Drifts have been excavated from four different points and, in three of these, seams of good quality salt have been proved. Extensions to the drifts were recommended.

Proposed topographical surveys in the Salt Range.

74. The Northern India Salt Revenue Department propose to have certain areas at Khewra, Makrach (32° 40′ : 72° 53′) and Kalabagh, surveyed on a large scale during the cold weather, 1935-36. Mr. Gee had recommended exploratory drifts for rock-salt in these three areas and while in the Salt Range this year he advised on the extent of the areas that should be surveyed.

Silver (see Lead-ore).

Tin-ore.

Mogok area, Burma.

75. Dr. Iyer reports that cassiterite has been found in the pegmatite dyke at Sakangyi (22° 54′ : 96° 21′) in the Mogok subdivision, in association with quartz and topaz, but that the occurrence is only of scientific interest. Columbite has also been reported from the same pegmatite.

Water.

Tube-wells at Loilem and Loikaw, Southern Shan States.

76. At the instance of the Commissioner, Federated Shan States, Mr. V. P. Sondhi was deputed to examine the possibilities of tube-well water supplies for the towns of Loilem and Loikaw,

According to Mr. Sondhi, Loilem (20° 55′ : 97° 34′, sheet 93 H/9-13) is situated at a height of 4,200 feet above sea-level in the heart of a well-defined synclinal basin composed of Silurian rocks, comprising a number of series and stages from the Valentian to Hercynian. Lithologically the rocks are divisible into flaggy shales at the bottom, phacoidal limestones in the middle, and soft mudstones at the top. The bottom shales are best exposed near the village of Panghkawkwo, E. S. E. of Loilem, where they dip to the west at 60° and have an estimated thickness of 150-200 feet. The overlying phacoidal limestones are well-bedded and tabular, and have strongly influenced the topography and drainage of the area,—the topography being pock-marked by a large number of circular funnel-shaped swallow-holes, and the drainage largely underground. East of Loilem they dip steadily in a westerly direction at 60° and their counterpart to the west of Loilem is represented by the sharp hills and swallow-holes west of the Military Police lines where the limestones dip to the east at 50°. The thickness of these beds is estimated to be slightly over 2,000 feet.

The mudstones which overlie the limestones are the youngest rocks of the syncline; with the exception of a few intercalated strong bands of limestone their character as regards grain and composition is very much the same throughout their thickness, which is estimated to be not much less than 2,000 feet.

The geological structure of Loilem being that of a syncline, in which a thick series of partially fissured limestones is enclosed between a lower and an upper impervious layer of clayey rock formations, theoretically provides ideal conditions for an artesian or sub-artesian supply from wells located along the axis of the syncline. Tapping a supply from near the base of the limestones is not, however, practicable at Loilem, as a bore-hole, to reach an effective depth, would have to penetrate too deep to be within the financial resources of the town. Financial objections also preclude the utilisation of water by pumping from the artificial lake which lies south of the Military Police lines, and the piping of water from a perennial spring which emerges 2½ miles W. N. W. of the town. For practical purposes therefore the upper mudstones are the only rocks which can be considered. These possess very poor permeability and a system of water supply, such as a tube-well, where free permeability is an essential factor, is unsuited to them. The present dug wells at Loilem, which are mostly fed from the more

permeable surface soil and sub-soil, yield enough water for the requirements of the town so long as the sub-soil remains saturated with meteoric waters. With the advance of the dry season, when the sub-soil is drained and seepage is confined to the fresher rocks below, the yield becomes very small. The flow into a well in such conditions is in direct proportion to the seepage surface tapped by it and in a tube-well such surface is naturally considerably reduced. It is obvious therefore that a tube-well cannot be recommended to replace the existing dug wells for the water-supply of the town. In the circumstances Mr. Sondhi recommends the improvement of the existing type of wells by increasing their depth and diameter and also by running infiltration galleries in suitable directions, so as to increase their seepage surfaces and storage capacities.

Mr. Sondhi thinks that this supply could be supplemented in individual cases by the collecting of rain water from the corrugated iron roofs with which most of the buildings of the town are provided.

Loikaw (19° 40′: 97° 13′—sheet 94 E/2), is the largest town of the Karenni States and is built on the banks of the Balu *chaung* which flows from the well-known Inle Lake. The oldest rocks of the area are represented by a series of mudstones of a deep red colour exposed on the western slopes of the hills to the south of town and also, in a fresher state, in the stream itself. These are unconformably overlain by Plateau Limestone which occurs in the form of sharp crags and rugged hills. Both these formations are covered by the thick mantle of lacustrine deposits of the flat Loikaw plain. At Loikaw these lacustrine deposits are between 70 and 80 feet thick and have been entirely cut through by the Balu *chaung* exposing a long line of scarp faces on either side of the stream. They are composed of poorly consolidated clays and loams of a light colour, without any visible bedding, and contain iron salts which give rise to a highly lateritised soil. A surface study and well records do not give any indication of the existence in them of freely permeable, coarse-grained beds, such as sand or pebble beds, although such deposits are liable to occur in shallow water deposits of this nature. In the absence of such evidence Mr. Sondhi cannot advise the sinking of a tube-well except for purely experimental purposes.

The only other source of water-supply available is the raising of water from the Balu *chaung*. This is a source that may best be left to the local Public Works Department to investigate. Re-

garding the present water-supply from dug wells, Mr. Sondhi remarks that during the rainy season the water table is practically level with the ground surface and the few wells north of the Balu *chaung* are full to the brim. With the advance of the dry season the water table drops steadily with the consequent drop in the water level in wells until, towards the middle of the dry season, the wells are dry. The general direction of the ground slope is to the west, towards the Ya lake, and wells in this direction are the last to dry up. On the extreme west the Ya lake retains a sheet of water throughout the year and its banks are always green and marshy. The level of this lake therefore appears to represent the level of permanent saturation. If this be true, then none of the present wells reaches this zone and all derive their supply from a temporary saturation of the lacustrine deposits in the rainy season. Another reason why the zone of permanent saturation can be expected to be near the level of the Ya lake is that, in a poorly consolidated homogeneous deposit like that at Loikaw, maximum concentration of water may normally be expected near its base where it lies upon the well-consolidated impervious mudstones, and this latter deposit cannot be far below the level of the lake. In view of these considerations Mr. Sondhi suggests that the present wells do not reach the zone of permanent saturation and that at least one well should be sunk deep enough to reach the base of the lacustrine deposits to ascertain the conditions of water concentration there.

Lower Chindwin district, Burma.

77. During the field-season 1934-35, Mr. V. P. Sondhi reported on the waterless tracts of the Lower Chindwin district. These are situated either on the Irrawadian series (Upper Tertiary) disposed in a synclinal basin, or on alluvium; of the latter there are deposits of both older and younger; the former crops out in certain localities only and is often covered by younger alluvium and a thick soil cap. It does not form a good source of underground water, and most of the waterless tracts east of Monywa are situated on it.

Tube-wells which go through the alluvium to tap the water in the Irrawadis may be ruled out, as the water in the Upper Tertiaries in Upper Burma is always saline and usually impotable, and in the alluvium here the limited percolation area of a tube-well would not give an adequate supply.

Mr. Sondhi discusses the various areas in detail and his general conclusions are to the effect that amelioration of the situation is

to be sought in sinking shallow wide-diameter wells, or by widening the existing ones and running infiltration galleries at any water-bearing horizon met with. Such wells, it would appear, do not usually need to exceed 30 feet in depth, though in two cases sweet water has been struck at about 80 feet.

Surface tanks are, of course, useful, but should be located in comparatively narrow valleys, preferably with steep gradients, and the surface area should be as small as possible in proportion to capacity, to reduce the loss by evaporation.

Rewa State, Central India.

78. In April, Mr. West paid a short visit to Rewa State to investigate the possibilities of increasing the water available for irrigation in the northern part of the State. The area investigated comprised the four *tahsils* of Satna, Rewa, Mauganj and Sirmaur. This area is part of a level elevated plateau, bounded on the south-east by the Kaimur range, and on the north and east by the escarpment which overlooks the plains of Allahabad and Mirzapur. The gentle northern slope of the Kaimur range gives rise to a number of streams flowing northwards across the plateau. The rainfall averages about 42 inches a year; but, owing to the scarcity of vegetation in this part of the State, the rain, as soon as it falls, rapidly runs off the ground into the streams and rivers, and is thus to a large extent lost to the State.

The geological structure of this part of the State is simple. It is a very shallow trough of Upper Vindhyans pitching very gently to the west. The centre of the trough is formed of the Lower Bhander sandstone, followed outwards successively by the Bhander limestone, the Ganurgarh shales, and the Upper Rewa sandstone. An examination of the water-bearing properties of each of these groups, as judged from the supply of water in the wells, showed that the only group likely to contain much water is the Bhander limestone. Since this group is underlain by impervious shales, the conditions appear to be favourable for the accumulation of underground water within the limestone. The volume of water which may be stored in this way is, however, rather problematical. In the first place the trough is so shallow, especially on its north side, that the conditions favourable for the storage of water, which are dependent on such a structure, can only be held to obtain to a very limited extent. In the second place, the limestone in question is, for the most part, so massive that the volume of water that it is

capable of storing is likely to be limited. To determine to what extent these limitations are serious, Mr. West has suggested that the two big wells by the new guest house at Rewa should be thoroughly tested by continuous pumping with efficient electric pumps, noting the rate of recovery of the wells. In addition he has recommended that three new deep wells be constructed in the centre of the trough. One of these may be constructed by deepening the well at the power house at Satna. A second should be constructed near Rampur on the Rewa-Satna road, and a third should be put down near Amilki, between Rewa and Govindgarh. These three wells should also be thoroughly tested. It might be thought that for the purpose of these experiments tube-wells would be easier and less expensive to construct than wells. But in view of the fact that the rate of flow of water within the Bhander limestone is likely to be slow, the very much greater surface provided by a large diameter well will be more efficient in supplying water from such strata than a narrow tube-well.

Summarily, while Mr. West is rather doubtful if the large amount of water required for irrigation can be obtained in depth from these rocks, he considers that in view of the great benefit to be obtained from an increased supply of water the tests recommended by him should be carried out.

Meerut and Moradabad districts, United Provinces.

79. At the request of the Chief Engineer, Irrigation Development, Mr. Auden was deputed in conjunction with Dr. McKenzie Taylor, Director of Irrigation Research, Punjab, to advise on problems connected with a scheme of tube-well irrigation in the north-western districts of the United Provinces. The Irrigation Department has embarked upon an extensive scheme of state irrigation from tube-wells, driven by Ganges Grid electricity. The final development will entail the running of 1,500 1½ cusec wells for 3,000 hours in the year over a total area of 3,600 square miles. The problem was whether or not such pumping would have a deleterious effect on the ground-water supplies of the districts concerned. The factors governing the supply of water to the ground are:—(1) local rainfall; (2) slow seepage from the Terai, where the rainfall is higher; (3) seepage from canals and canal-irrigated lands; and seepage from the areas irrigated by water pumped out from the tube-wells.

Dr. McKenzie Taylor is concerning himself with a statistical examination of the rainfall and water-table records, with the influence of seepage from canal-irrigated lands, and with accurate laboratory determinations of the transmission co-efficients of the water-bearing sands.

Mr. Auden emphasises that the areas in which tube-well pumping is confined should not be considered as isolated units independent of the neighbouring areas where there is less demand for water drawn from the ground, but that they should be regarded as part of the Gangetic alluvial system, which, east of the submerged extension of the Aravalli range from Delhi towards Dehra Dun, occurs in a single basin almost certainly without underground barriers of any magnitude. While rainfall is probably the dominant factor in controlling the level of the ground-water in individual districts it is a safe conclusion that the continuity of the alluvium in this basin permits the greater rainfall supply of the Terai belt being operative as a means of replenishment in the area to the south. A study of the tube-well records shows that sands predominate over clays and also that correlation is very seldom possible between the strata of even closely situated wells. The strata are lenticular, and the predominance of sands suggests that the clays should be considered as lenticles enclosed within a more general matrix of the sands. This indicates that the water in the sands occurs as a continuous reservoir, which must be connected with the strata below the Terai where the rainfall is greater. Even assuming the most unfavourable conditions—an annual rainfall of 20 inches (which is the average of three different periods of three consecutive years of lowest rainfall at Meerut) and no percolation of the irrigation water from the wells back into the ground, Mr. Auden calculates that there is a considerable excess of rainfall over the water removed by pumping. Both Mr. Auden and Dr. McKenzie Taylor were impressed by the porosity of some of the superficial sands and by the fact that percolation back into the alluvium must be considerable. Taking into account the interconnection of the water-bearing sands, the influence of the higher rainfall zone of the Terai, and the percolation of water pumped out from the wells back into the alluvium, Mr. Auden considers that there is little danger of the lowering of the water-table as a result of this irrigation scheme.

80. In October, Dr. C. S. Fox visited Madhupur (24° 16′ : 86° 38′) in order to advise the authorities of the East Indian Railway on

the question of augmenting the supplies of water for the railway locomotives and staff. The total quantity of water required was 20,000 gallons per day. The present source of supply for the staff is derived from a number of wells, and for locomotives it is obtained from a tank to the west of the station, the tank being kept filled by pumping from the Titia *nala* about one mile south-west of the railway station.

Madhupur, E. I. Ry.

Dr. Fox states that the rocks exposed consist mainly of gneisses with irregular lenticles and veins of pegmatite. He observed a prominent seepage of fresh water in the railway cutting between miles 183 and 184 on the Main Line to the N. N. W. of Madhupur Station and advised the sinking of a deep well in a recess on the west side of the cutting between miles 183/7 and 183/8 with, if necessary, a gallery running from the bottom of the well beneath the railway cutting. As an alternative, he suggested that the present well No. 1 might be deepened and a similar underground gallery driven towards the above-mentioned cutting.

He further suggested that the supply of the Titia *nala* pumping tank might be greatly improved both in quantity and quality by excavating a wide-diameter well to a depth of 25 to 30 feet below the bed of the *nala,* immediately on the upstream side of a prominent dolerite dyke which crosses the stream-bed just below the present pumping station.

81. Dr. Dunn visited Kamptee in September to advise on the possibilities of a water supply for the Cantonment. Up to the present a large number of private and military wells have supplied the water requirements, but it is now proposed to utilise the considerable amount of reserve power at the Power Station in some form of pumping scheme.

Kamptee, Central Provinces.

The Cantonment area is covered by alluvium to an average depth of 40-50 feet, but the evidence available indicates that a ridge of schists and gneiss underlies the alluvium here, striking W. N. W. To the north, across the Kanhan river, Kamthi sandstones crop out and the boundary between Kamthi sandstones and gneisses is either a fault or a very steep north-dipping surface.

It has been proposed to sink bore-holes in the Power House compound with the hope of obtaining the necessary water supply; but such a scheme is unlikely to yield the 180,000 gallons per day required.

Bore-holes along the bank of the Kanhan river into the porous Kamthi sandstones near their junction with the gneiss are an alternative scheme,—previous boring here had demonstrated the possibility of obtaining 8—10,000 gallons per hour from one borehole; but the water was of a hard nature. The scheme is not favoured because of the uncertainty of obtaining the necessary supply.

The most certain source of supply at Kamptee would be from a large well sunk in the river-bank at the sharp bend opposite Goreghat, at a point west of Camp Equipage Godown No. 4, and west of the tributary *nala* which enters the Kanhan just west of the bungalow. The well would be on the low ground about 30 feet from the river-bank, and the pump house would be situated on the high ground a few yards further south, above flood-water level. This situation is almost ideal for this type of well. If the supply is insufficient from the well itself, after taking it down to bedrock, a short gallery, driven out below the river, should give all the additional infiltration required.

GEOLOGICAL SURVEYS.

Burma Circle.

82. During the field season 1934-35, the Burma Circle consisted of Mr. E. L. G. Clegg (in charge), Messrs. E. J. Bradshaw, V. P. Sondhi, Drs. H. L. Chhibber, M. R. Sahni and L. A. N. Iyer. Mr. Bradshaw was stationed at Yenangyaung as Resident Geologist and on his proceeding on leave on 22nd April, 1935, Mr. Clegg took over the duties of Resident Geologist in addition to his own.

Myitkyina district.

83. The field season had hardly begun when Dr. Chhibber, who had proceeded to the Myitkyina district to continue his survey in the Jade Mines area, became ill and was unable to continue his work. As a result, the survey of the Jade Mines area was not continued.

Thayetmyo district.

84. During January and February, Mr. Clegg was engaged on the completion of work along the Eocene-Pegu boundary in sheets 85 I/15 and I/16 in the Thayetmyo district. During the 1923-24 field season Mr. Clegg worked in this area but was unable to find any evidence for fixing the Pegu-Eocene boundary between Thakutkyaw (19° 18′ : 94° 54′),

and west of Thapangyo (19° 5′ : 94° 57′) to the south.[1] As a consequence the boundary was left as originally mapped by Theobald.[2]

The Eocene-Pegu boundary, as revised by Mr. Clegg as a result of his recent work, is adumbrated in Theobald's map by the limestones shown as occurring south and west by south of Thapangyo.

The area examined, which is included between the Thayetmyo-Mindon road (latitude 19° 23′) and the Made *chaung* (latitude 19°) and longitudes 94° 47′ and 95°, forms a diagonal running N. N. E. and comprises Upper Eocene and Lower and Middle Pegu rocks.

The Upper Eocene rocks consist of shales, alternating flaggy sandstones and shales, false-bedded and lenticular sandstones of a massive character, and foraminiferal limestones. The foraminiferal limestones are in general associated with the more shaly bands in the series, although foraminifera do also occur as reefs and isolated tests in some of the sandy rocks. Were it not for the foraminiferal limestones it would be difficult, if not impossible, to fix an upper boundary to the Eocene. As it is these limestones are intermittent in character and at times have the habit of striking at an angle to the ridge of high ground which they form; they dip for the greater part in conformity with the other Eocene rocks in a north-easterly direction at an average of about 30°. In sheet 85 I/15, on the Thayetmyo-Mindon road, they are met at mile 28·2 and occur intermittently from here to the south-east for about six miles, where they are cut off abruptly by faulting. They are bounded on the south-east by a cross fault which runs in a south-west by west direction and forms a fault scarp north-west of Shwenattaung Pagoda. These Eocene foraminiferal rocks were picked up again eight miles to the S. S. W. in sheet 85 I/16 and were traced from there in a south-east by south direction to Pingadaung on Made *chaung*. Faulting in these Upper Eocene rocks is common.

The Pegu rocks, from where the Eocene rocks are cut off six miles south of the Thayetmyo-Mindon road, consist of a massive series of rather shaly fine-grained micaceous sandstones, weathering out in lenticles in the harder bands and spheroidally in the thin, softer and more shaly intercalations. They form the high Theobyit Taung-Myitmyin Taung ridge, which is made up of a series of scarps and dip slopes striking north-west to north. The dip slopes are at angles of 40° or more and are often bare of vegetation and

[1] *Rec. Geol. Surv. Ind.*, LVIII, Pt. 1, p. 45, (1926).
[2] *Mem. Geol. Surv. Ind.*, X, Art. 3, Map, (1873).

extremely difficult to traverse. On the summit of the ridge castellated effects are produced. Northwards these rocks have a very poor development on the east side of the Eocene-Pegu boundary, thinning out from 3,000 feet to little more than 500 feet. The series is fossiliferous but fossils become more scanty south of the Mindon *chaung*, where the same series is found in the faulted anticline which forms the Wetchan Taung-Taungnyo range and in the syncline to the westward in the rocks which form the ridges of Nale Taung, Sima Taung, Kyein Taung, Yebok Taung and the hills north of Kyaukme.

This sandstone series passes gradually upwards into a shale series which can be followed down the Pyinaing-Satle valley, through Aukmanein, Singaw and Kyaukpadang and thence to the south-east to underlie the Prome sandstones west of Kama; it passes downwards into a fine, blue, spheroidally weathering shale series which can be seen (1) due south of Thakutkyaw, (2) in the core of the faulted Wetchan Taung-Taungnyo anticline and again (3) forming the valleys of Pyagyi Monda, Gyinye, Yebokkale, Peinnekwin and at Kyaukme. A local sandstone horizon is sometimes present above the Eocene foraminiferal limestone horizon and can be seen west of Monda and Gyinye and north-west of Peinnekwin in sheet 85 I/16 and east and south-east of Thakutkyaw in sheet 85 I/15. The above horizons can be identified with the Yaw stage, (foraminiferal limestone), Shwezetaw sandstones, Padaung clays, Okhmintaung sandstones and Pyawbwe clays of Lepper,[1] and a very similar section can be made out further north about latitude 19° 32′, where the Okhmintaung sandstones are again strongly developed in the ridge from which they presumably take their name, although thinning out to the east, where they reappear as the sandstones of the Monatkon and Okpon domes and possibly in the anticlinal folds further east.

85. From the latter part of March to the end of the season Mr. Clegg completed the 4-inch sheet survey of the Mogok Stone Tract by a more detailed examination of certain areas, and in this work he was assisted during April by Dr. Iyer.

Mogok Stone Tract.

The rock groups were the same as mentioned in last year's General Report.[2]

[1] World Petroleum Congress, London, 1933, Vol. 1, p. 16.
[2] *Rec. Geol. Surv. Ind.*, LXIX, p. 51, (1935).

A short visit was paid to the Kyauktalon area to see if it was possible to put in a definite boundary between the so-called Mogok series and the schists to the south. No definite boundary between the two areas could be made out and although the change from the biotite-garnet-gneiss to the schist series can be said to be gradual, gneissose schists are found interbanded with biotite-garnet-gneisses in the north and with mica-schists in the south, whilst tourmaline-granites are found intruded into both series. South of the Nampai Chaung, however, where no intrusions of tourmaline-granite were met, phyllites alone were found. In this transitional area the lenticular sheets of tourmaline-granite give rise to the hills and the biotite-garnet-gneisses and schists to the valleys. The schists are very poorly seen, as they are deeply weathered to a thick red soil-cap whilst the country is thickly forested.

Kyauktalon.

In addition to the mapping of a few more small outcrops of crystalline limestone in association with the syenite in the Ongaing Reserved Forest, north of Mogok, the main mass of the syenite which runs through Ongaing village was found to continue westwards as a thin band into the Yebu valley. On the north side of the Yebu valley, where the Mogok-Kyauknaga track crosses it, the rock is still definitely an augite-syenite consisting of microperthite, orthoclase, augite, apatite and iron-ores, sometimes a little plagioclase also being present. Towards Yebu, in the isolated outcrops in the paddy fields, the rock is more acid in character and contains a fair amount of quartz; westwards along the Uyin Chaung this granitic character prevails to Thapanbin where the augite or hornblende-syenite and granite series dies out. North of Yebu and Thapanbin small outcrops of white crystalline limestone with phlogopite, spinel and graphite were noted, caught up in the series.

Mogok.

The numerous crystalline limestones mapped south of Kyaukthinbaw Taung in the north of the Ongaing Reserved Forest are intruded by syenite and pegmatite, the pegmatite being a coarse whitish rock composed of felspar and smoky quartz, usually seen cutting through the limestone or capping it and occurring in a similar manner to the exposures seen on Chinthe Taung north-east of Kathe.

On the south-east of Lada Taung, the jagged crystalline limestone hill immediately north of Mogok town, which continues east

wards to unite with the southern end of the Letnyo spur, occurs an exposure of weathered garnet-gneiss which takes off from the eastern end of the Injauk valley. This band is obscured by debris in the flats west of Myenigon but is seen again cutting into the south end of the Letnyo spur; it thins out to the east and is overlain by crystalline limestone in the Letnyo spur only to reappear again as a pear-shaped outcrop underlying the huts north by east of Myenigon. Eastwards it is again covered by limestone for a few yards but crops out again in the knoll which protrudes from the stone diggings to the east. The rock is a light-coloured medium to coarse-grained garnetiferous gneiss and consists of orthoclase, garnet, and quartz in rounded inclusions in the felspar. A little micrographic texture occurs.

Oksaung Taung (22° 56′ 40″ : 96° 32′ 40″.)

On the south-west spur of Hmyaw Taung, at a height of 5,200 feet, a very irregular pegmatite of graphic granite continues intermittently to the steep valley immediately north-west of Oksaung Taung. In the valley to the east of this spur only decomposed calcareous gneiss and pegmatite debris can be seen to the 'col' north-east by north of Oksaung Taung, where the pegmatite which cuts through Hmyaw Taung from the Pinpyit area as a continuous exposure is met. In the valley on the east side of Oksaung Taung, with the exception of a little calcareous gneiss, only pegmatite is exposed. The manner in which the sharp Oksaung Taung peak is reinforced by pegmatite veins is very reminiscent of the occurrence of pegmatite veins in the sharp peak of Pingu Taung in the Kyatpyin valley.

Thondaungmyaing.

Thondaungmyaing is a mountain only three miles north-east of Mogok as the crow flies, but is concealed from the town by the intervening Letnyo spur. Its southern flank is composed of limestone which dips in a direction north of east and appears to have been at one time continuous with the limestone of the Onbin Yedwet spur to the south-east. Anastomosing pegmatite veins, which are well seen at the summit of the peak, penetrate the crystalline limestone. One such vein towards the western flank consists of garnet-granite and pegmatite and runs practically from top to bottom of the hill. The pegmatite is of a coarse texture and contains 'books' of mica up to four inches across and large quartz and felspar crystals. Some parts show graphic granite in which the quartz is of the smoky variety. On

the eastern flank of the exposure pegmatites predominate, coarsely crystalline limestone occurring caught up in them.

On the western flank occur some old workings opened up by the late Burma Ruby Mines Company in very coarsely crystalline limestone, the calcite rhombs of which attain sizes of over one foot across. The crystalline limestone includes crystals of phlogopite, graphite and diopside.

Bernardmyo.

In the Bernardmyo area an exposure of eclogite was found by Dr. Iyer, E. S. E. of Ywathit at a height of 5,950 feet, whilst a few more exposures of khondalite were noted on the west side of the Bernardmyo road and some isolated exposures of limestone in the thick forest on the northern slopes of Mawgiwa Taung.

Thabeitkyin-Kin Chaung area.

Before joining Mr. Clegg, Dr. Iyer mapped on the one-inch scale the area lying between the Kin Chaung and the Irrawaddy river on Survey of India old sheet No. 239 (93 B/1 and parts of 93 B/5 and 84 N/3 new).

In addition to the rocks mentioned in the Mogok area, Dr. Iyer was able to map hornblende-schist or epidiorite, and mica-schists and hornblende-granulite of the Tawng-Peng system. These latter rocks of the Tawng-Peng system are the ones south of Kyauktalon above-mentioned (page 59).

Adjacent to the Irrawaddy a narrow strip of Irrawaddy sandstones dips westwards into the river; they form a low ridge of medium to coarse-grained false-bedded sandstones and are cut off, according to Dr. Iyer, from the Mogok series to the east by a boundary fault. Major patches of gravel and silicified fossil wood which occur to the east 700 feet above, on the shelf which the Mogok road traverses between miles 4 and 10, show the once greater extent of this series.

Tawng-Peng system.

The mica-schist series of Mong Long is found to continue in a westerly direction from the Mogok area and to pass south of Laungzin (22° 51′ : 96° 24′). Included in this series are hornblende-granulites, whilst tourmaline-granites intrude it.

Basic and ultrabasic intrusions.

Basic and ultrabasic rocks are found as pyroxene and hornblende-pyroxene types in the vicinity of Shwenyaungbin (22° 55′ : 96° 20′) and E. N. E. of Onhmin (22° 46′ : 96° 8′) but their occurrence is very rare.

Kabaing granite.

The Kabaing granite occurs in the eastern part of the area mapped in continuation of the main occurrence of the Mogok area. Westwards it occurs intermittently as small bosses and bands intrusive into biotite-gneisses and crystalline limestones.

Syenite and syenite gneisses.

Syenite and syenite-gneisses were noted, although rarely. They have a similar mineralogical composition and occurrence and are always found in close association with the crystalline limestones, as in the Mogok area.

Quartzite.

Quartzite occurs either as a more arenaceous facies of the calcareous suite of rocks or as a replacement of calcareous gneisses and is best seen near Kyaukhlebein (22° 54′ : 96° 13′) as a lenticular mass associated with limestone and calc-gneiss.

Calc-gneiss.

Calcareous gneiss, scapolite-gneiss and diopside-gneiss occur as marginal bands, inclusions or impure bands in the crystalline limestones.

Crystalline limestones and calciphyres.

Crystalline limestones and calciphyres attain their greatest development west of longitude 96° 11′, as three trough-like folds intruded by granites, whilst at their western termination they are folded in with gneisses and hornblende-schist.

On the shelf mentioned as traversed from miles 4—10 of the Mogok road, the crystalline limestones are practically horizontal, although in places Kabaing granite and other rocks of the Mogok suite do penetrate them in hump-backed ridges. These crystalline limestones are often very fractured and in the more coarsely crystalline exposures graphite, phlogopite and spinel are commonly present; in the medium-grained and granulitic contact bands calcite, diopside, forsterite, chondrodite, sphene, scapolite and iron-ore are also present. The limestones may be either calcitic or dolomitic.

Hornblende-schist and hornblende-gneiss.

Hornblende-schist and hornblende-gneiss are confined to the area adjacent to the band of Irrawaddy sandstone north and south of Thabeitkyin (22° 53′ : 96° 1′); they also form massive hills and steep cliffs north and south of Ponna (22° 49′ : 96° 1′). Hornblende-schist is also seen folded with crystalline limestone and biotite-gneiss in stream sections.

Biotite-garnet-sillimanite-gneisses.

Although no typical khondalites were mapped in the area, biotite-garnet-sillimanite-gneisses were found to have a local occurrence.

Unclassified crystalline rocks.

The unclassified crystalline group of rocks which occupy the greatest area mapped, includes numerous petrological types of both intrusive and sedimentary origin and their metamorphic derivatives, which, owing to their relatively small occurrences could not be mapped separately; the rocks of the series vary from coarse-grained normal biotite-granites to biotite-pyroxene-granites, hornblende-granites, biotite-garnet-gneisses and biotite-garnet-sillimanite-gneisses. South of Laungzin the Mogok series passes gradually into the mica-schists of Monglong.

South of Yamethin.

A granite which was noted by Mr. Clegg 41 miles south of Yamethin on the main Rangoon-Mandalay road, on sectioning proved to be almost identical in mineralogical composition and characteristics to the Kabaing granite. Further specimens have been collected with a view to analysis.

Southern Shan States.

86. Mr. V. P. Sondhi continued his work in the Southern Shan States. This comprised during the 1934-35 field season—

(1) The continuation of systematic mapping of the Lawksawk and Yengan States.

(2) The continuation of a traverse along the Paunglaung valley.

(3) Short visits to Loilem and Loikaw to explore the feasibility of tube-wells for the water-supply of these towns (*see* Water, pages 48 to 51).

In the Lawksawk and the Yengan States a large portion of sheet 93 C/11-15 was mapped and the survey of sheet 93 C/12-16 was completed. Apart from the superficial deposits of alluvium and residual earth, the development of which in 93 C/11-15 becomes restricted in a northerly direction, the geological formations present in this sheet are essentially a continuation of those occurring in the southern adjoining sheet 93 C/12-16. The southern portion of the area covered forms a large basin through which the Zawguin *chaung* has carved a straight course to the north, but to the north and on the east and west the country becomes extremely

hilly, and the configuration is strictly governed by the rock formations present. Thus the easily weathered brecciated Plateau Limestone occupies the heart of the basin and gives rise to low undulating hills and rolling plains; the higher levels along the flanks of the basin on the west are covered by Lower Palaeozoic mudstones belonging to the Pindaya formation; the well-defined hilly zone beyond the mudstones is covered by a limestone and siltstone formation belonging to the Mawson series, and to the west of this zone lies a great expanse of mountainous country, made up of Chaung Magyi rocks. In the Mawson series and the Pindaya beds some fossil horizons characteristic of these formations were discovered, an interesting feature of their occurrence being that this is the first time in the Southern Shan States that more than one group of Lower Palaeozoic rocks has been met with in the same section. Their position in the geological column has of course been known from their fossil contents.

On the east, the Zawgyi basin is flanked by hill ranges composed of the Ordovician formations above-mentioned and these in turn are overlain by deposits of Silurian age. Some miles to the south of this sheet a traverse was made across the same hills along the road to Mong Ping where an almost complete succession of Lower Palaeozoic rocks was met with. The succession started with the Mawson series of Middle Ordovician age and ended with the *Tentaculites* beds of the topmost Silurian or Hercynian. Among the latter a new horizon was discovered containing isolated specimens of a brachiopod resembling *Meristia,* in association with innumerable specimens of *Tentaculites elegans.*

The greater part of the eastern half of sheet 93 C/12-16 is occupied by a large inlier of Chaung Magyi rocks which forms the high range north of Pindaya and has peaks of 7,678 and 7,362 feet. The inlier is surrounded, on the three sides so far examined, by rocks of Lower Palaeozoic age. On the east and south these rocks are directly overlain by mudstones of the Pindaya beds, but on the west of the inlier they have been recognised only in the northern portion of the sheet, where they form a short band; otherwise throughout the length of the sheet the Chaung Magyis are bordered by rocks of the Mawson series, which consist generally of characteristic blotchy limestones. In one place, near Kyauknget, the limestones are succeeded by Pindaya beds which in turn underlie graptolite beds of the Llandovery stage. A curious feature of

these Palaeozoic rocks is that the whole succession dips to the east at high angles, apparently below the Chaung Magyis, suggesting the presence of a thrust-fault bringing the older Chaung Magyis over the Palaeozoics, but in spite of a close search not a single section was discovered where the relationship of the two rock formations could be actually seen. The Palaeozoic rocks appear to continue to the north, ending up against a westerly extension of the Chaung Magyi inlier, and it is hoped that further work will reveal the true nature of the junction of these deposits.

With the exception of a small outlier of Red Beds exposed in the Paunglaung valley in the extreme south-west, the remainder of the western part of sheet 93 C/12-16 is occupied by Plateau Limestone.

The Paunglaung valley survey.

The traverse along the Paunglaung valley, which had to be postponed by Mr. Sondhi last season, was resumed in the season 1934-35 at Taloktwin, a village situated near the confluence of the Paunglaung *chaung* with the Maha *chaung*, in sheet 93 C/12. The Paunglaung *chaung* here follows a straight course to the S. S. E. to the southern end of the sheet, and beyond, in sheet 94 A/9, along the faulted junction of the Plateau Limestone with a series of highly disturbed shales, slates, tuffs and quartzitic sandstones. The age of this sedimentary series is doubtful and is likely to remain so until a larger area has been mapped systematically. Throughout its length in these sheets the valley is overshadowed on the east by an enormous wall-like scarp of Plateau Limestone, rising from 2,000 to 3,000 feet above the bed of the stream. At the foot of the scarp the sedimentary series is exposed, dipping to the east and forming a hilly belt of country from three to four miles wide. In a few places near the junction with the limestones it is intruded by diorite and porphyry and these intrusions have also affected the limestones. On the west the sedimentary series is intruded extensively by granite, which is exposed along the western margin. Rock exposures are very rare in the valley, as they usually lie under a thick cover of pebble and clay beds, deposited by the stream itself in Pleistocene or sub-Recent times. The present stream has cut through the entire thickness of this deposit and is now actively engaged in cutting into the older rocks beneath.

The granite on the west is a medium-grained biotite type, of light colour, traversed by well-developed regular joints running at

intervals in a N.N.E.—S.S.E. direction and giving the rock a bedded appearance. At one place, near Sizongon on the Maha *chaung*, a series of hot springs with a temperature of 128°F. (in January, 1935) issues from these joints.

Southern Shan States and Kyaukse district.

87. During a comparatively brief field season, Dr. Sahni continued the survey of parts of the Southern Shan States and the Kyaukse district, completing the unfinished parts of sheets 93 C/13 and 93 C/9 and continuing southwards into the north-east corner of sheet 93 C/14 and the north-west corner of sheet 93 G/2.

With the exception that overlying the Chaung Magyi rocks and underlying the fossiliferous lower Palaeozoic sediments a series of hard blue and purple sandstones, shales and grits with occasional intercalations of conglomerate occurs at certain places, the succession of rocks mapped by Dr. Sahni was identical with the sequence found in the area previously surveyed to the north.

La Touche, in his 'Geology of the Northern Shan States', mentions the occurrence of lithologically similar beds resting upon the Chaung Magyis and assigns to them a lower Namshim age[1]. J. Coggin Brown named similar but unfossiliferous beds overlying the Bawdwin volcanic tuffs as the Pangyun beds and attributed to them a lower Cambrian or Ordovician age[2]. Later G. V. Hobson also recorded similar rocks from other parts of the Northern Shan States and correlated them with the Pangyun beds[3]. Although no fossils have been found in the purple beds in the area under survey, further search might reveal their presence and the question of their age must, therefore, be left undecided for the present. These beds appear to rest conformably upon the Chaung Magyi rocks and pass without a break into the fossiliferous sediments above.

In sheet 93 C/13 the belt of Plateau Limestone does not extend continuously far south of the area previously mapped, though it crops out again and extends in a narrower belt into the sheet adjoining to the south.

Lithologically the Plateau Limestone presents the same characters as reported last year, and except for one locality, a little to the south of Kongtawnghsu (21°. 44′: 96° 59′), where a species of

[1] *Mem. Geol. Surv. Ind.*, XXIX, p. 132 and p. 135, (1913).
[2] *Rec. Geol. Surv. Ind.*, XLVIII, Pt. 3, p. 146, (1917).
[3] G. V. Hobson, Progress report for the field season 1928-29, p. 39,

foraminifera occurs profusely, no fossils have been found in the dolomitic type.

Plateau Limestone occurs also as small outliers in sheets 93 C/9 and C/13. One of these outliers is crossed along the old footpath from Hele (21° 46′ : 96° 45′) to the Kyangin Chaung, about two miles to the east of the former. Another outlier constitutes the flat ground around Ongyaw (21° 47′ : 16° 43′) to the south of which village it is brought against Chaung Magyi rocks by a fault. Plateau Limestone also caps the isolated the gently undulating tract south-east of △ 1977 (21° 51′ : 96° 38′) which constitutes an impressive panoramic feature in the midst of very broken and dissected country.

The Ordovician and Silurian formations were mapped together, partly on account of the frequent changes in lithology which the rocks have undergone, and also because, owing to considerable crushing, very few determinable fossils could be found in them. *Tentaculites elegans*, a characteristic Silurian pteropod, was, however, recognised at several localities, as, for example, along the scarp north-east of △ 1977 (21° 51′ 30″ : 96° 38′), at several points south-east of Nam-hu-gyi and again on the footpath running along the Nam Tu, not far east of the junction of the Myaung Ka *chaung* and the Nam Tu.

Lithologically these lower Palaeozoic rocks are identical with the rocks of the same age mapped during the previous field season, and are composed of yellow or variegated clays and shales, purple shales, phacoidal limestones and fine-grained sandstones.

The Chaung Magyi rocks occupy extensive areas in sheets 93 C/9, 93 C/13, and 93 C/14. Lithologically they are identical with those previously reported.

Structurally the area is an anticlinorium, the Chaung Magyis, the oldest rocks, being overlain successively by (1) the purple beds, (2) fossiliferous lower Palaeozoic (Ordovician and Silurian) sediments and (3) the Plateau Limestone.

Northern Circle.

88. During the field season 1934-35, the officers working in the Northern Circle consisted of Dr. A. M. Heron (in charge, Mewar and Danta States), Messrs. W. D. West (Simla Hills), J. B. Auden (United Provinces), H. M. Lahiri (Punjab) and P. N. Mukerjee (Northern Bombay).

Dr. Heron was in charge of the Circle until the 17th September 1935, when he was appointed to officiate as Director and handed over charge of the Circle to Dr. C. S. Fox.

Singoli, Gwalior State, and Mewar, Rajputana.

89. At the beginning of the season Dr. A. M. Heron mapped the boundary between the Ganurgarh shales and the Bhander limestone (Vindhyans) in the Singoli *tappa* of Gwalior State, in sheets 235 and 236 (old numbers) on the one inch scale.

He then proceeded to north-western Mewar (Udaipur State) to make a final study of the banded gneissic complex there in one-inch sheets 242 and 243 (old numbers). Different parts of this had been mapped by Dr. S. K. Chatterjee, Mr. B. C. Gupta and Dr. Heron, and as there are certain differences in lithology between the north and the south, the possibility had to be explored that the northern portion might be Aravallis and that a boundary between it and the southern portion, where the Aravallis rest unconformably on the banded gneisses, had been missed. This was found not to be the case, and there is no real distinction, but a complete transition, between the northern and southern types. The lithological difference between the two was found to be due to the prevalence in the north of a dark highly biotitic intrusive granite which first appears in sheet 143, as an isolated boss, becomes abundant in sheet 142, and all-pervasive to the north-east, in north Mewar and Ajmer-Merwara.

Near Amet (25° 18′ : 73° 58′, sheet 142) two large anticlinal domes of sedimentary quartzite rise from beneath the banded gneisses, dipping concordantly with the foliation of the latter. Their presence, evidently as a basal part of the gneissic complex, indicates that, apart from its igneous constituents, it was originally a sedimentary formation. The igneous intrusives have invaded and almost obliterated the upper pelitic (now mica-schist) portion of the succession, and have left the lower quartzite portion almost unaffected owing to the comparative impermeability of the latter to igneous intrusions.

Danta State, Bombay.

90. Early in January 1935, Dr. Heron proceeded to Danta State, formerly in Bombay Presidency, but now under the Western Rajputana States Agency. This had previously been geologically surveyed extra-departmentally by Mr. N. L. Sharma[1], but its resurvey was necessary as

[1] *Q. J. Geol. Min. and Met. Soc. Ind.*, Vol. III, No. 1, (Feb. 1931).

it forms a link between the surveys of Middlemiss in Idar State, Coulson in Sirohi State, P. K. Ghosh in Idar and Palanpur States, B. C. Gupta and P. N. Mukerjee in northern Bombay and Heron in Mewar. It happened, in fact to be the "key-stone in the arch" of the geology of Rajputana and northern Bombay, which Dr. Heron and his colleagues have brought to completion in the field-season under review. Danta State and the small estates of Gadhwara and Sudasna in the Sabarkantha Agency of the States of Western India Agency are comprised in the one-inch sheets 45 D/15, D/16, H/3 and H/4.

Danta, with the adjoining State of Idar, sees the obliteration of the synclinorium of the Delhi system to the south by the Erinpura granite cutting across it, and the disappearance of the rocks under the alluvium of Gujarat.

Sedimentary rocks are represented by the highest group of the Ajabgarh series at the top of the Delhi system. They consist of highly contorted calc-gneisses, permeated and isolated by ramifications of the Erinpura granite, and are succeeded upwards by a great thickness of grey limestones, forming a syncline in the core of which is an oval of phyllites, the youngest rocks of the Ajabgarhs anywhere seen.

The Erinpura granite is present in nearly all its protean variations. A fairly homogeneous, coarse, porphyritic, biotitic type, that of Erinpura itself, forms a great mass covering the western third of the area examined; finer grained, non-porphyritic, less biotitic and more variable types, often banded, streaky and foliated, occupy the central third of the area, and appear to be more in the form of sheet intrusions or lenses than large masses. They are probably contemporaneous with each other, and are on the whole slightly earlier than the coarse-grained material of the large western intrusion, but there are gradations between them all.

The eastern third of the area is occupied principally by the Ajabgarh sedimentaries, with the granite intruded into them in many different forms, and showing excellent examples of junction phenomena,—granite and aplite veins in calc-gneiss, and swarms of amphibolite xenoliths in the granite, derived from the calc-gneisses.

The main interest has been the linking up of Mr. C. S. Middlemiss' surveys in Idar in sheets Bombay 119, 145, 146 with those which have recently been in progress on all sides of Idar.

Idar correlation.

It has previously[1] been stated that Middlemiss' scheme of succession in the sedimentary metamorphics is inverted; his order is a perfectly natural conclusion from the evidence available to him, as his Phyllite series, in reality the Aravalli system, is much less metamorphosed and intruded by igneous rocks than his 'calc-gneiss' and 'biotite-gneiss', which belong to the Ajabgarh series of the Delhi system. These Ajabgarhs are in a deeply folded syncline, while the Aravalli phyllites are outside it. It has now been ascertained that Middlemiss' 'calc-gneiss' comprises both Heron's 'calc-gneisses' and 'calc-schists', the middle and upper divisions of the Ajabgarh series. In describing the Mundeti series, Middlemiss pointed out their similarity to his calc-gneisses, but that they were metamorphosed to a less degree, and that their general character was as if they had been metamorphosed thermally rather than dynamically. The outcrops north of Mundeti are not penetrated by aplite veins, but the Erinpura granite and granite-porphyry intrude them at five places on their periphery. On visiting the Mundeti series, Heron was struck with their great likeness to the 'calc-schists' of the Ajabgarh series, except in their finer and incipient crystallisation.

The Mundeti outcrops are on the strike-continuation of a long narrow synclinal valley in which are Ajabgarh calcareous slates and thin limestones equivalent to the calc-schists. This valley syncline ends seven miles to the north of the Mundeti outcrops, by the swinging of the Alwar quartzites round its end. Again, just to the north-west of the Mundeti outcrops, is the opening of another synclinal valley in which poor exposures of the Ajabgarh biotite-schists are seen some miles to the north, to which Middlemiss did not have access; the calc-schists are not seen in this valley, either because the synclinal fold is not deep enough to bring them in, or that they are covered by alluvium. If we assume a normal fault, running N. W.-S. E. along the north-east of the Mundeti outcrops, this would connect up the Mundeti outcrops with the rocks of the first-mentioned valley if its downthrow were to the south-west and with the rocks of the adjoining second valley if its downthrow were to the north-east, all the beds dipping at high angles to the south-east. Middlemiss suggests such a fault (and has shown it in pencil on his field-map) from the brecciation of the hornstone plastered along the northern

[1] *Rec. Geol. Surv. Ind.*, LXV, Pt. 1, pp. 143-44, (1932).

slopes of the 1,153 foot spur[1] of the Mundeti outcrop, and the sheared platy structure and twisted strike of the nearest adjoining outcrops of Alwar quartzite.[2]

The unconformity between the Delhis and Aravallis was all but detected by Middlemiss. The Aravallis ('Phyllite series') *immediately* below the base of the Delhis are everywhere concealed in Idar, but Middlemiss divided the quartzites of Idar into two categories,[3] (*a*) *a region* ('*expanded*') *of broad outcrop areas*, and (*b*) *a region* ('*contracted*') *of narrow outcrop areas which twist about in a complicated way*, using his own apt description of the characteristic physiographical differences between the Alwar and Aravalli quartzites respectively. The valley of the Hathmati river marks the boundary between these two regions, which is in continuation of the Delhi-Aravalli junction as mapped by Heron in Mewar. There are lithological differences between the two sets of quartzites, but rhe most important feature is the way in which the Aravalli quartzite ridges strike at all angles to the straight line of the Alwar quartzites.

There is no doubt that the Idar granite of Middlemiss is the Erinpura granite, and not the Jalor-Siwana granite of La Touche. Middlemiss states that it continues westwards and northwards to join up with the Siwana and Jalor granites,[4] but the continuity is with the Erinpura granite, not with those of Jalor and Siwana, which are separated from Idar by the huge Abu-Erinpura batholith of Erinpura granite. The aplite veins in the calc-gneisses are one of the earliest phases of the Erinpura granite, and though in the Dharol[5] and Vasna[6] sections described by Middlemiss and examined by Heron the granite is later than, and cuts, the aplites, there are elsewhere in Rajputana transitions between them. Though in Idar the granite is unfoliated and generally coarse in grain, in the adjoining State of Danta we have transitions from this late type to the finer grained, more acid, streaky and foliated forms which are believed to be early arrivals while compressive stresses were still in action.[7] Apparently in the limited and isolated exposures in Idar we have a very early and a very late type, with the intermediate

[1] *Mem. Geol. Surv. Ind.*, XLIV, Pt. 1, p. 57, (1921).
[2] *Ibid.*, p. 61.
[3] *Ibid.*, p. 79.
[4] *Ibid.*, p. 118.
[5] *Ibid.*, pp. 19-21, 125.
[6] *Ibid.*, pp. 118-19.
[7] *Op. cit.*, LXIII, Pt. 1, p. 77, (1933).

linking variations absent, and here again, the clues being missing, Middlemiss could not but infer, on the evidence available to him, that the aplite and granite were of different ages.

The presence of quartz-porphyries and granite-porphyries of the Erinpura suite is a unique feature of Idar, not having been recorded elsewhere, and helped to mislead Middlemiss in correlating it with the Jalor and Siwana granites, which in Sirohi are associated with the almost contemporaneous porphyries of Malani age.

91. Owing to Mr. W. D. West having to leave the Simla Hills to investigate the Quetta earthquake, he was able to devote only five weeks to his work in this area. This was spent entirely in the Nauti *khad* and on the southern slopes of the Shali mountain, north-east of Simla, on the one inch sheets 53 E/4 and E/8. Detailed work on the scale of two inches to one mile has brought out the great complexity of this area.

Simla Hills.

The south side of the Shali range is a dip-slope of Shali limestone, overlain by the Shali quartzite, and this by the Madhan slates. Further south, on the south side of the Nauti *khad*, these rocks are overlain by the Chail series, which in turn dips south-west beneath the Simla slates of Simla. In addition, thin intermittent outcrops of Subathu beds are found overlying the Madhan slates. The late Sir Henry Hayden first discovered these Tertiary beds, and further outcrops were subsequently found by the late Capt. R. W. Palmer, and others by Dr. G. E. Pilgrim. The detailed mapping of this area has now revealed that not only are the Subathu beds more extensive than was previously thought, but also that they are succeeded around Katnol (31° 10′ : 77° 15′) by Dagshai beds, consisting of carmine shales and purple and green sandstones.

This is important, since it had hitherto been thought that Tertiary beds younger than Subathu were confined to the south side of the Barog boundary fault.

Of special interest is the occurrence of a large outlier of the Chail series on the slopes of the Shali mountain north of the Nauti *khad*, at and south-west of Katnol. This overlies all the other rocks, from Dagshai to Shali limestone, with marked discordance, and testifies to the reality of the Chail thrust. It is evident that the Chail series once continued right over what is now the Shali mountain, and that the thrusting must have been post-Dagshai.

Also of great interest are the complicated structures developed beneath the Chail thrust in the Shali limestone, Shali quartzite, and Madhan slates in the neighbourhood of Dharmpur (31° 10′: 77° 19′). These rocks are thrown into several flat recumbent folds, there being three main folds. The uppermost fold is itself composed of smaller folds. These folds are in most places separated from each other by very clear, nearly horizontal thrusts, which have cut out the middle limbs of the folds, and so caused the Shali quartzite to overlie the Shali limestone, the two being highly crushed at the junction. In one place the Shali limestone, forming the core of the uppermost fold, has been squeezed out into a huge isolated lenticle. It seems likely that the recumbent folding and thrusting were directly induced by the Chail series as it travelled over the area from north to south.

Dehra Dun district and Tehri-Garhwal State, United Provinces.

92. Mr. J. B. Auden spent most of the period from January to July in continuing the survey of the Himalayan foothills in the neighbourhood of Mussoorie. This work was interrupted in 1934 on account of his being deputed to examine the effects of the Bihar-Nepal earthquake. The area covered is included within one inch to the mile sheets 53 F/15 and 53 J/3, and half inch to the mile sheets 53 J/N. W. and 53 J/S. W.

The Blaini-Krol-Tal succession is very well displayed in a syncline the axis of which passes through Bata Gad (30° 27′: 78° 7′). The upper Krol limestones have been mapped to the south-east as far as hill 6482 (30° 17′: 78° 16′) on the south limb of the syncline and hill 7979 (30° 22′: 78° 18′) on the north limb. East of longitude 78° 7′ the Blaini consists of two boulder beds separated by banded bleaching slates, of Infra-Krol type, and greyish quartzites. The upper boulder bed is associated with the pink magnesian limestone which is so typical of the Blaini in the Solon area. West of longitude 78° 7′ the lower boulder bed is not found, since it is apparently overlapped by the upper boulder bed and limestone. The upper Krol limestones are mostly almost pure dolomites. At the top of the upper Tal quartzites between Ringalgarh (30° 21′: 78° 14′) and Silla (30° 22′: 78° 10′) Mr. Auden found a dark shelly limestone full of broken lamellibranchs and brachiopods, which he regards as the same as the upper Tal limestone of Middlemiss, which was mapped east of the Ganges river in 1887. The thickness

of the Blaini-Krol-Tal succession in sheet 53 J/3 is of the order of of 10,000 feet.

Overlying the Tal rocks east of Dehra Dun occur two thrust units :—the Mandhalis, consisting of slates, quartzites, boulder beds and a sandy limestone strongly resembling the Bansa limestone, and a series of schistose phyllites which belong almost certainly to the Chandpur series. In the western part of the thrust outlier, the Chandpurs lie upon the Mandhalis, but to the east the Mandhalis, together with the Tal fossiliferous limestone, are cut out, and the Chandpurs rest directly upon upper Tal quartzites. The thrust unit of Chandpur schistose phyllites is well exposed on hill 6533 (30° 22′ : 78° 11′) and by Kujni (30° 20′ : 78° 16′). Mr. Auden states that there is no doubt about the thrust position of these rocks, now occurring as outliers, upon the Tals. The structure is the clearest that he has seen along the whole Krol belt so far mapped. The finding of a fossiliferous limestone overlain by schistose rocks near Dehra Dun almost completes the parallel between the succession mapped by Middlemiss in 1887 east of the Ganges and the succession worked out in the last five years west of the Ganges and Mr. Auden believes that a re-examination of the structure in Garhwal will establish the overthrust nature of the Inner Schistose series of Middlemiss, a suggestion which Middlemiss himself put forward but which he rejected on the grounds of improbability.[1]

In sheets 53 F/14 and 53 F/15 the Blaini appears to lie unconformably upon the Nagthats and the Nagthats to cut across the Mandhalis and Chandpurs. It is possible that these are two unconformities and indicate considerable earth movement in late Palaeozoic times. Mr. Auden suggests that the Chandpur phyllites should be separated from the Nagthat rocks, which are almost certainly the equivalents of the Jaunsar series near Simla, and should be regarded as a separate series. East of Dehra Dun there is an abrupt change in metamorphism from the Mandhalis, which are thrust upon the Tals, upwards to the overlying schistose phyllites of the Chandpurs, and it seems probable that these two formations are themselves separated by a thrust which is distinct from the thrust which has brought both of them to lie upon the Tals. Between Kalsi and Chakrata the Chandpurs similarly overlie the Mandhalis. Until the evidence was obtained this year east of Dehra

[1] *Rec. Geol. Surv. Ind.*, XX, pp. 36, 37, (1887); LXVI, p. 470, (1933).

Dun, Mr. Auden had preferred to regard this succession as a normal one. Now, however, he believes it possible that a thrust may divide these formations between Kalsi and Chakrata. A difficulty at once arises, because the Chandpur-Mandhali boundary is apparently truncated by the unconformably overlying Nagthat beds, and, if this boundary is a thrust, it follows that the age of the thrusting must be pre-Nagthat. Orogenic movements of Palaeozoic age have not previously been recognised in the Himalaya. Mr. Auden's provisional explanation is that a pre-Nagthat thrust caused the superposition of the Chandpurs upon the Mandhalis, while a Tertiary thrust has brought both these units to rest upon the Tals east of Dehra Dun.

Mr. Auden draws attention to the similarity between the Tanawals (Tanols) of Kashmir and the Nagthat beds. Both are continental formations, both show very varied degrees of metamorphism and both present anomalous relationships with the formations surrounding them. He suggests that the Palaeozoic unconformity emphasised by Mr. Wadia for the western part of Kashmir may have extended to the south-east as far as the lower Himalaya by Dehra Dun, and that both Tanawals and Nagthats may represent a continental facies connected with late Palaeozoic earth movement along this zone.[1] The magnitude of this movement is not at present known. Much depends on whether the boundary between the Mandhalis and the Chandpurs is really a thrust and on whether this boundary is actually truncated by the Nagthat beds, as the mapping indicates.

Bhagirathi river and Gangotri area, Tehri-Garhwal State.

93. During October and the early part of November, Mr. Auden spent a period of leave in a reconnaissance of the Gangotri neighbourhood, Tehri Garhwal State, examining portions of degree sheets 53 I, J and N. The route was from Mussoorie over the east shoulder of Nag Tibba and up the Bhagirathi valley as far as the snout of the Gangotri glacier. After mapping the snout of the glacier, Mr. Auden turned up the Kedarnath glacier to a height of 16,000 feet. A return was made to Gangotri and the Rudagaira *nala* was then followed up as far as the glacier field, after which a height of 19,000 feet was reached on one of the Gangotri peaks lying to the west. Finally the Nela valley was ascended to about 12,000 feet. The rocks encountered along the Bhagirathi valley as far as

[1] *Rec. Geol. Surv. Ind.*, LXVIII, p. 144, (1934).

Sini (30° 46′ : 78° 35′) consist of three groups in the following apparent sequence :—*top*, schistose phyllites, resembling the Chandpurs; a thick series of quartzites; *bottom*, limestones and slates. The quartzites are well exposed from longitude 78° 30′ eastwards to Sini, and show a striking resemblance to those seen at Chamoli (30° 24′ : 79° 20′) in 1932. Along this part of the valley, as along the Alaknanda, there are extensive intrusions of basic rocks, now in the condition of epidiorites. Still further north-east these are converted into hornblende-schists.

After Sini there is an abrupt change from sheared quartzites to the overlying schists and gneisses. These crop out along the whole length of the Bhagirathi river as far as to two miles east of Dharali (31° 03′ : 78° 50′), in a series with monotonous north-easterly dips. The peaks Kedarnath and Gangotri are built up of para-gneisses and schists. There is a great variety of rock types, of which the following are the most prominent :—biotite-granulite with pin-head garnets; biotite-schist; kyanite-schist; garnet-actinolite-zoisite-granulite, sometimes with free calcite; garnet-chlorite-schist. The parent rocks were shales, shaly sandstones, calcareous shales and grits. Free calcite is not common, and the suite is decidedly less calcareous than the calciphyres cropping out between Badrinath and Mana. These metamorphosed sediments are followed northwards by intrusive granite. The boundary is distinct and runs from about 30° 52′ : 79° 3′ up the Kedarnath glacier, through the Rudagaira *nala* at 30° 57′ : 78° 55′, the Bhagirathi river two miles east of Dharali, to the Nela valley about two miles north of Harsil. This granite forms the peaks of Satopanth, and is the same as that seen in the Arwa valley in 1932. It is extremely variable, being in the region about Gaumukh (30° 55′ : 79° 7′) and the Kedarnath glacier strikingly tourmaline-bearing, to the exclusion of biotite, but passing westwards to tourmaline-muscovite granite, and, by Harsil, to biotite-muscovite granite. It is often porphyritic, and sometimes gneissic, the phenocrysts being drawn out into *augen*. The quartz is sometimes in granular patches and the granite has in places been highly sheared. Thus the boundary between the granite and the overlying metamorphics at a height of 10,300 feet up the Nela valley is marked by a zone of schistose and mylonitised granite 130 feet in width (measured at right angles to the contact). Mr. Auden suggests that the granite was intruded before at least the final earth movements and was either pre-tectonic or syn-tectonic. The granite

has given off an extensive series of pegmatites and aplites which are intrusive into the underlying metamorphics. The pegmatites normally bear tourmaline, and garnet is not an infrequent constituent. He comments also on the richness of some of the Nagthat arkoses in the Mussoorie area in microperthitic felspar and on the fact that microperthite is common in the Gangotri granites, and remarks that there is some measure of support for the idea of a Palaeozoic age for these granites. The peaks on the north-east side of the Bhagirathi valley between Gangotri temple and Gaumukh consist of roof-pendants of dark metamorphic rocks floating upon granite.

Kangra, Hoshiarpur and Ambala districts and Patiala, Nalagarh and Mailog States, Punjab.

94. During the field-season 1934-35, Mr. H. M. Lahiri, in continuation of his previous work, mapped portions of sheets 53A/1 and A/2, lying in the Kangra and the Hoshiarpur districts, and portions of 53A/16, B/9, B/13 and B/14, situated partly in the Ambala district and partly in the Patiala, Nalagarh and Mailog States.

The geological formations met with are, in ascending order, the Nahan or Lower Siwalik, the Middle Siwalik, the Upper Siwalik (including the Pinjors,[1] boulder conglomerates and *dun* beds) and sub-Recent and Recent deposits.

The lithology of the various formations is in general the same as noted for them in previous reports.

The hills adjacent to the Pinjaur (Pinjor) *dun* from Kalka (30° 50′ : 76° 56′, 53B/13) north-westwards through Nalagarh (31° 2′ : 76° 44′, 53A/12) consist of alternations of sandstones and clays, the latter preponderating over the sandstones in the lower beds. These lower beds, which are well seen on the faces of the cliffs that rise abruptly from the *dun*, exhibit a characteristic banded appearance due to the presence of yellow and purple clay bandings in the reddish brown clays. While working in the Nalagarh area in field-season 1933-34, Mr. Lahiri had mapped these strata as Dagshai, following Dr. Pilgrim's unpublished maps of the area. Having, however, since seen the Dagshai formation in its type-locality, he is now of opinion that the Kalka and Nalagarh beds are not Dagshai as thought by Dr. Pilgrim, but Nahan. Dr. Heron agrees with him, as during the Puja holidays he made a tour of the type sections and the disputed beds in question (*see* pages 19 to 22).

[1] The name is now spelt Pinjaur on the topographical maps, (30°47′ : 76°55′).

Structurally, the portion of the Siwalik range lying in the north-western quarter of sheet 53A/2 is an anticline of Upper Siwalik rocks which is followed on the north-east by a flat syncline of *dun* deposits occupying the valley of the Soan river. The almost horizontally disposed *dun* beds are faulted, on the north-east, against disturbed Pinjor rocks (with a few inliers of Middle Siwalik) that occur on the south-west fringe of the Bharwain (31° 48′ : 76° 8′, 53A/1) range. This fault is the north-westerly continuation of the Satlitta fault noted in the Director's General Report for 1933.[1] The crestal region of the Bharwain range and a large part of its north-east flank are occupied by thick Upper Siwalik boulder conglomerates which dip at low angles in a general north-easterly direction. For the greater part of the Beas-Banganga valley in 53A/1, the solid geology is concealed under a thick mantle of sub-Recent boulder-beds and Recent alluvium, but there is sufficient evidence to indicate that this valley, in its northern part, coincides roughly with the axial region of an asymmetric syncline of Upper Siwalik beds. This syncline is succeeded north-eastwards by a south-east pitching anticline of which the core is formed by Nahan rocks constituting the Managarh (31° 56′ : 76° 13′) ridge, the fold being in the same tectonic line as the Sola Singhee flexure of 53A/5 and A/6. The ridge with peak 2301 north-east of the Managarh ridge also consists of Nahan beds which are overlain by Middle Siwalik strata with north-easterly dips. Between the Managarh ridge and that to its north-east is a highly compressed syncline of Middle Siwalik beds, the junction of which with the Nahans on either side is partly normal but partly a faulted one.

The portion of the Pinjaur *dun* lying between the Ambala-Kalka railway line and Nalagarh in sheets 53A/12, A/16 and B/13 consists of almost horizontally disposed boulder-beds and clays which are seen to pass quite conformably downwards into the Upper Siwalik boulder-beds in the area to the south of Pinjaur (30° 47′ : 76° 55′, 53B/13). West of Pinjaur, however, the *dun* beds are in faulted contact with the Pinjor strata of the Siwalik range, the fault, which is of the overthrust type, running north-westwards along the south-west fringe of the *dun* until it dies out west of Nalagarh. The north-eastern limit of the *dun* is marked by another prominent thrust-fault which has brought the Nahan beds forming the Kalka and

[1] *Rec. Geol. Surv. Ind.*, LXVIII, p. 67, (1934).

Nalagarh hills into juxtaposition with the *dun* deposits on the south-west. Mr. Lahiri notes that the Nahan sandstones occurring in close proximity to the fault are, as a rule, slickensided and brecciated.

Mr. Lahiri also visited, during the season, the type-areas of the Dagshai, Kasauli and the Nahan formations to compare sections.

Nahan State, Punjab.

The stratigraphical zones occurring near Nahan (30° 34′ : 77° 17′, 53F/6) are separated from each other by faults and are arranged, from north to south, in the following order:—

(N).
Subathu
————————*Fault.*
Nahan
————————*Fault.*
Upper Siwalik boulder conglomerates.
————————*Fault.*
Upper Siwalik Pinjor beds.
(S).

Mr. Lahiri notes that the faults separating the Upper Siwalik boulder conglomerates from the Nahans on the one hand and the Pinjors on the other are both of the type of thrust-faults like those noticed on either edge of the Pinjor *dun* in 53B/13.

The Siwalik beds examined by Mr. Lahiri during the season yielded fragmentary and ill-preserved vertebrate fossils at places, but near Basawi (30° 49′: 76° 52′, 53B/13) he obtained several well-preserved specimens belonging, amongst others, to the *Elephantidæ*, *Hippopotamidæ* and the *Bovidæ*.

Kaira and Ahmedabad districts, and Mahi Kantha States, Bombay.

95. Mr. P. N. Mukerjee mapped portions of the (1) Thasra and Kapadvanj *talukas* of the Kaira district, (2) Parantij *taluka* and Modasa *mahal* of the Ahmedabad district, (3) Mahi Kantha States of Malpur, Idar, Ranasan, Mohanpur, Ilol and Derol.

The ground surveyed is included in standard sheets 46 A/14, E/2, 6, E/3, 7, E/4, 8, E/11, 15, F/1, 5.

The geological formations of the area are the Aravallis with intrusive granites (Erinpura?), the Lametas, the Ahmednagar sandstones, the Deccan trap and Recent and sub-Recent alluvial soils.

The Aravallis consist of phyllitic schists often associated with fine to coarse-grained pink and grey quartzites. The Aravalli quartzitic bands constitute some of the main hill ranges in the area,

forming a series of parallel strike ridges running persistently over several miles with a general E.N.E.-W.S.W. direction, the beds being either very steeply inclined or vertical. An extensive exposure of the Aravalli phyllites and quartzites has been mapped east and south-east of Modasa (73° 20′ : 23° 28′). This has been followed well into the Idar State and found to be continuous with the 'Phyllite Series' mapped by Middlemiss. The general character and association of the 'Phyllite Series' are identical with those of the Aravallis mapped in the neighbouring areas. The strike of these phyllites and the associated quartzite beds is N.N.E.-S.S.W. Thus these argillaceous and arenaceous metamorphics join up with the Aravallis mapped by Dr. A. M. Heron and Mr. B. C. Gupta in the north and east of the area as well as with the 'Transitions' of Kishen Singh in the south.

The principal intrusive in the Aravallis is a massive form of granite, weathering into monolithic masses and ovoid bodies. The granite occurs in patchy outcrops forming rocky mounds and 'tors'. The granite is sometimes foliated and shows banded structure, being often associated with aplitic veins. It varies in texture from coarse to medium and fine-grained types, varying in colour from milk-white to pink-grey and contains quartz, felspar and biotite mica as its essential constituents.

It is believed to be the same as the Erinpura granite of Rajputana.

An outcrop of the Lameta formation has been mapped south of Gabat village (73° 23′ : 23° 15′), a portion of which was mapped by Kishen Singh as 'Vindhyan'. The formation is a typical Lameta rock consisting of gritty siliceous limestone, weathering grey, well jointed and almost horizontal.

Early in 1860, Kishen Singh mapped a few disconnected patchy outcrops of coarse-grained gritty sandstones, varying in colour from white to pink and dark red or chocolate brown, as 'Vindhyans'. These rocks appear, however, to be identical with the Ahmednagar sandstones mapped by Middlemiss in the Idar State. The Ahmednagar sandstones are often associated with highly ferruginous shales and clays (*see also* pages 23 and 29).

A few outcrops of dark-coloured basalts have been found in the area, outliers of the Deccan trap mapped by Messrs. Kishen Singh and B. C. Gupta. The trap is vesicular, and is characterised by spheroidal weathering.

Post-Tertiary (Recent and sub-Recent) deposits of soil, alluvium, and *kankar* irregularly overlie the Aravallis and the younger formations of the area.

Southern Circle.

Southern Circle.

96. During the field season 1934-35 the officers working in the Southern Circle were Dr. C. S. Fox (in charge; Assam), Mr. H. Crookshank (Central Provinces and Madras), Mr. W. D. West (Central Provinces), Dr. P. K. Ghosh (Central Provinces), Mr. D. S. Bhattacharji (Central Provinces), Dr. A. K. Dey (Bihar and Orissa), and Mr. A. M. N. Ghosh (Assam). Dr. A. L. Coulson took over charge of the Circle in the recess period until Mr. Crookshank's return from leave (from 18th September to 16th November, 1935).

Assam, Khasi and Jaintia Hills.

97. After returning from leave, from Abyssinia, in November 1934, and assisting in the preparation of the Quinquennial Review during December, Dr. C. S. Fox proceeded to the border of Sylhet and the Khasi Hills to initiate Mr. A. M. N. Ghosh in the geology of the Shillong plateau. Dr. Fox stayed with Mr. Ghosh until the end of January in the area about Therria Ghat and then left him to investigate the relationship of the Cretaceous and overlying Eocene strata. Last season[1] Dr. Fox had come to the conclusion that the Cherra sandstones, together with the so-called Cretaceous coal of Mawbelarkar, were of Tertiary age and related to the overlying Sylhet limestone and consequently distinct from the true fossiliferous Cretaceous of Therria Ghat. He had indicated certain strata below the Sylhet limestone and above the Cretaceous sandstone of Therria Ghat as being the possible equivalent of the Cherra sandstone. He therefore left Mr. Ghosh to settle the question and to confirm what Dr. Fox had already found, that the Cherra sandstone was unconformable to the underlying Cretaceous and conformable with the Eocene beds above. These details are dealt with in the following summary of Mr. Ghosh's work. They confirm Dr. Fox's opinions and he will discuss the stratigraphy of the

[1] *Rec. Geol. Surv. Ind.*, LXIX, p. 82, (1935).

Assam Tertiaries in his memoir on the Tertiary and Mesozoic coal-fields now in preparation.

98. After leaving Mr. Ghosh at Therria Ghat, Dr. Fox travelled to Shillong *via* Sylhet and the new motor road *via* Jaintiapur, Dawki and Laitlynkot, and then proceeded to Damra, where he resumed his survey of the Garo Hills. He mapped southward from Damra (25° 56′: 90° 47′; sheet 78 K/NE, two miles to one inch) up the Dudnai valley to its watershed about Dambu (25° 40′: 90° 50′). He then connected westward with his earlier survey near Songsak (25° 38′: 90° 37′) before continuing down the valley of the Rongtham to the Simsang about Chimagiri (25° 28′ : 90° 41′) and into the so-called Daranggiri coalfield. Throughout the traverse southward from Damra, gneissic rocks are seen up to the Simsang. They have a foliation which trends roughly north and south with dips both east and west at high and low angles. The strike may vary from north-east to north-west, but this is clearly due to buckling and folding. The gneisses include veins and lenticles of pegmatitic material, which in some places is greatly contorted without itself developing a gneissic structure. With the gneisses must also be included some 'green-stones', possibly epidiorites, though now found as hornblende-schists and gneiss. East of the Rongtham stream near Dobu (25° 33′ : 90° 42′) there are magnetite-quartzite rocks which at first suggest the Iron-ore series of Singhbhum. These curious rocks were found again west of Chimagiri and appear to have been folded in with the gneisses. It is possible that they remain in such isolated positions partly owing to faulting.

Garo Hills.

Kaolinised gneisses and thick deposits of kaolin are seen in the valley of the Rongtham from near Naringgiri (25° 37′ : 90° 42′) southward. They are well developed in the valley south-east of Dobu and further south. They correspond with the same horizon, at the base of the Assam Tertiaries, around Tura and elsewhere in the Garo Hills. They are never pierced by the dolerite dykes which Dr. Fox has also noted in the gneissic areas in the Garo Hills. Many such dykes were encountered between Damra and the Simsang, and are regarded by him as of the same age as the Sylhet trap, *i.e.*, possibly the same as the Rajmahal traps. Practically all the stone celts which are so common in the Garo Hills are made of this Mesozoic doleritic basalt. Under the microscope it is almost indistinguishable from Deccan trap. In some cases it occurs as strong

dykes, but in numerous exposures it is found as sill-like intrusion in the gneisses, and ometimes with inclusions of gneiss. Dr. Fox noted in a case near Singrimari that this doleritic material had also undergone kaolinisatio , and he had previously regarded this kaolinisation as contemporaneous with a period of lateritisation at the dawn of the Tertiary era in India (*see* page 34).

The kaolin beds in the Rongtham near Nengkhra Agalgiri (25° 31′ : 90° 42′) are covered with clays and sandstones and a thin seam of lignitic material. South of the Simsang from Chimagiri these beds are well seen with easterly dips which bring in the Eocene coal measures of the Darangfield so clearly exposed at Darang Rongmuthupathal (25° 27′ : 90° 42′; sheet 78 K/SE). Here the seam is quite six feet thick and is of good quality. The coal horizon dips eastward and so is missing to the west at Darang Boldakgithim, where the gneisses show up from under the kaolin horizon. However, the kaolin and the coal bed occur on the high ground east of the Simsang above Rongbinggiri (25° 29′ : 90° 37′), and this village stands on higher Tertiary strata containing marine fossils which indicate their equivalence with the Sylhet limestone stage. A strong north by east fault throwing westwards brings in these Lower Tertiary marine beds—l rgely impure limestones and shales, like those of Damalgiri west of Tura—in the upper valley of the Simsang. The kaolin beds and coal-bearing horizon reappear from beneath these marine strata near the Forest Camp above Rongrenggiri, but in this vicinity the coal seams encountered are thin and worthless, so far as Dr. Fox's observations have allowed an opinion to be formed.

Although these Tertiary formations—from the kaolin zone at the base, to the impure nummulitic limestones above—lie in the upper valley of the Simsang, they do not occur on the high ground to the south or north. The Tura range separates them from the main outcrop of Tertiary strata which form an apron to the Assam range from beyond Shillong to the spurs towards the Brahmaputra south of Dhubri. In Dr. Fox's opinion these rocks, which form part of the so-called Daranggiri and Rongrenggiri coalfields, have been faulted down within the Assam range itself, and must therefore have covered the Tura range and had a northward extension almost to what is now the Brahmaputra valley of Assam. The kaolin of Naringgiri found this season and the exposures about Songsak and further north-west found previously by Dr. Fox support this view.

It simply means that the Eocene sea must have extended practically over the whole Shillong plateau at the time the Sylhet limestone was laid down.

Dr. Fox is of the opinion that at the close of the Cretaceous period, land did exist on what is now the Shillong plateau, but that subsidence was in progress. During this epoch laterite-forming and kaolin-forming conditions existed on the land. Ultimately the Eocene period saw the submergence of the land and the deposition, first, probably under marshy conditions, of the coal measures and the kaolin, then of the limestones of Siju, and later of the shales, *etc.*, of Rewak. These three stages correspond roughly with the Cherra stage of Cherrapunji, the Sylhet limestones of Therria Ghat and the Kopili beds of the geologists of the Burmah Oil Company. They are all of Lower Tertiary age.

Khasi Hills.

99. During the first half of his stay in the Khasi Hills, Mr. A. M. N. Ghosh devoted his attention to the rocks of the southern area lying between Nongiri (25° 12′ : 91° 48′) on the east and Shella (25° 11′ : 91° 39′) on the west. Later he ascended the main plateau and proceeded through Cherrapunji (25° 17′ : 91° 44′) and Sohrarim (25° 21′ : 91° 45′) to Laitlyngkot (25° 27′ : 91° 50′) where he closed camp about the middle of May. The area is included in Survey of India sheets 78 O/11, 12, 15 and 16.

In the course of his field-work, Mr. Ghosh made out the following succession of rocks :—

Low-level alluvium	Recent to sub-Recent.
High-level gravels	
Sandstone and shale with earthy limestone . . .	Upper and Middle Tertiary.
Nummulitic and *Alveolina* limestones	Lower Tertiary.
Cherra sandstone and its equivalent	
Earthy limestone, calcareous shale, massive sandstone and conglomerate	Cretaceous.
Sylhet trap	? Jurassic.
Shillong series	Pre-Cambrian.

(*Granite and epidiorite intrusives into the rocks of the Shillong series.*)

The younger Tertiary rocks are found in the outer foothills south of the Cherra plateau and consist of fine-grained soft, greenish grey sandstones with subordinate shale bands. These beds have at their base a ferruginous 'pudding-stone' (?)—a weathered fossiliferous band showing occasional casts of gastropods. It rests upon a thick

band of shales carrying intercalations of thin, earthy limestone rich in *Discocyclina* (*Orthophragmina*) and other foraminifera.

This succession of beds is underlain by an alternation of limestones and sandstones attaining a very complete development on the eastern bank of the river at Therria Ghat. There are four limestone bands separated by sandstones of variable thicknesses. The uppermost limestone is mostly built up of large and medium sized *Nummulites*, the next lower one is an *Alveolina* limestone, while the third limestone band shows sections of gastropods and tiny foraminifera. The fourth or the lowest limestone is practically devoid of fossils. Mr. Ghosh suggests that the name 'Sylhet limestone' should be used to indicate the three upper fossiliferous limestone bands, together with the interbedded sandstones. The lowest limestone is separated from the beds of the Sylhet limestone by a considerable thickness of plant-bearing sandstone in the Therria *nala* and itself grades downwards into an earthy limestone and calcareous shales. Mr. Ghosh considers the plant-bearing sandstone, together with the underlying pure limestone, to be the equivalent, in the southern area, of the Cherra beds of the main plateau. There seems to be a substitution of the calcareous facies of the southern area by an arenaceous facies as the beds are traced northwards from Therria Ghat to Cherrapunji.

The impure earthy limestone and calcareous shales that follow yielded, in the neighbourhoods of Nongiri and Mahadek (25° 13′: 91° 44′), several Cretaceous ammonites and other fossils. In the opinion of Mr. Ghosh, they form the highest beds of the Cretaceous series both on the Cherra plateau and in the southern area. They are underlain by a soft, ochreous, fossiliferous, earthy sandstone and a massive sandstone of considerable thickness, the upper part of which is rich in fossils. In the Um Niuh, north of Barpunji Bazar (25° 11′: 91° 49′), the sandstone passes downwards into a ferruginous, calcareous sandstone having pockets of a coral limestone and a conglomeratic shell limestone at base resting on an ash bed of the Sylhet trap. This lower horizon yielded several bivalves, including *Protocardium* and a giant *Inoceramus*, and several brachiopods and ammonites. It appears that the lower band is represented on the Cherra plateau by the basal conglomerate north of Sohrarim.

As a result of his field work between Cherrapunji and Mawbehlarkar (25° 24′: 91° 45′) Mr. Ghosh arrives at the conclusion that the Cherra sandstone oversteps all the fossiliferous Cretaceous beds and

rests directly on the basal sandstone and conglomerate near Mawbehlarkar. The same opinion was expressed by Dr. Fox in last year's General Report. It would be in accordance with field evidence to group the Cherra sandstone with the overlying beds of the Sylhet limestone stage, there being no visible sign of any physical break.

During the last few weeks of his stay in the Khasi Hills, Mr. Ghosh had an opportunity of working in the metamorphic and intrusive rocks of the Shillong plateau. Mr. Ghosh found that the quartzites of the Shillong series were intruded by an epidiorite (the Khasi greenstone of Medlicott) first and later by a granite (Mylliem granite).

100. Dr. A. K. Dey was the only officer working in Bihar and Orissa and Bengal during the field season 1934-35.

Midnapore and Bankura districts, Bengal, and Manbhum district, Bihar and Orissa.

He mapped, in continuation of his previous season's work, portions of the Midnapore, Bankura and Manbhum districts lying in sheet 73 J/9. The geological formations of the area are in ascending order (1) the Iron-ore series with interbedded lava flows and sills, (2) intrusive granitic rocks and (3) the Newer Dolerite dykes.

The mica-schists of the Iron-ore series around Bagdiha (22° 51′ : 86° 43′) contain intercalated bands of calc-granulite composed of quartz, microcline, plagioclase, diopside, tremolite, hornblende, sphene and iron-ore. To the south of Kuilapal (22° 50′ : 86° 38′), the mica-schists have been intruded by an elliptical mass of granite which has produced *lit-par-lit* injection along the margins. In the north, the granitic rocks exhibit various degrees of metamorphism ranging from massive granular rocks to banded gneisses. Inclusions of older metamorphic rocks, consisting of epidiorite, hornblende-, chlorite-, talc-, and mica-schists, occur throughout the granitic regions. In the north-eastern part there are numerous small, dyke like bodies of altered basic rocks bearing a petrological resemblance to the Newer Dolerites.

Silicified fault-breccias are seen in a number of places in the mica-schist and granite-gneiss, indicating post-granite faulting.

Bastar State, Central Provinces and Jeypore Estate, Vizagapatam district, Madras.

101. During the field season Mr. Crookshank continued his mapping in Bastar and Jeypore. He completed sheet 65 F/15 begun in the previous year, and mapped portions of sheets 65 F/11, 1, and 5. In addition he examined fossil localities at Deothan, Khairi, and Budhimai on sheet 55 F/7.

The rocks mapped were as follows:—

Recent.	High level laterite.	
	Unconformity.	
Purana.	? Cuddapahs.	Shales, phyllites, slates and schists. Limestones. Quartzites.
	Unconformity.	
Archaeans		Dolerite. Charnockite.
	Greenstones	Metamorphosed basalts. Epidiorites.
		Granite and pegmatite.
	Bailadila series	Banded hematite-quartzites, and iron-ores. Banded hematite-chlorite and hematite-grünerite rocks. Earthy and chloritic hematites and ferruginous shales. Brecciated ferruginous schists and ferruginous conglomerates. White quartzite.
		Granitic gneisses with associated pegmatites and hornblende-schists, injection-gneisses.
	Bengpal series	Andalusite -gneisses, -schists, -slates, -sandstones. Sericitic and massive quartzites, quartz-, chlorite- and mica-schists, hematite- and magnetite-quartz-schists.
		Banded grünerite-quartzites.

The arrangement is as far as possible in chronological order with the youngest rock at the top of the list, but in many cases the ages of the various rocks are still uncertain. The designations 'Bailadila series' and 'Bengpal series' are local terms and may prove in the future to be merely temporary, as it may be possible to correlate them with some of the well-known divisions of the Peninsular Archæans.

High level laterite covers the top of the Bailadila ridge. Associated with it are pisolitic laterites and lithomarges suggesting the possible occurrence of bauxite beneath the ferruginous surface of the laterite.

The most interesting point in connection with the Cuddapahs is that their south-eastern boundary is a straight line, and therefore probably a fault. The western boundary is very irregular, and probably approximates to a boundary of deposition.

Dolerite and epidiorite dykes have been found together in the same area. It is concluded that they belong to two distinct periods.

Numerous outliers of charnockite were noted east of Malakangiri and in other places in the gneissic region west of the main charnockite area. As similar outliers have been reported by all previous workers in the region west of the Eastern Ghats it is concluded that they are a normal feature along the margin of the charnockites.

Epidiorites and metamorphosed basalts occur in many places, but especially on sheets 65 F/5 and 1. The latter overlie the Bengpals and gneisses with marked unconformity. They were also seen in contact with the Bailadila series, and it was provisionally concluded that they overlie these with unconformity also. Some of the epidiorites are undoubtedly intrusive in the basalts.

The Bailadila series, a local name for the Iron-ore series of southern Bastar, is very well represented in the Bailadila range. Here it seems to overlie the Bengpals, and underlie the basalts with unconformity. It is thought, however, that the evidence for these two unconformities is as yet inconclusive.

The granites and gneisses have been divided into the following three sub-divisions :—

(1) Newer granites and pegmatites, which appear to have escaped all folding and are little metamorphosed.

(2) Granitic gneisses, which appear to have been folded along with the sedimentary series.

(3) Injection gneisses of uncertain age and origin. Hill ranges of metamorphosed sedimentary rocks occur in all the field sheets mapped. With the exception of the Bailadila series all have been mapped as Bengpal on account of their lithological similarities.

An attempt has been made to separate the Bengpals into two stages, the younger of which is markedly aluminous, and characterised by the presence of andalusite, while the older is siliceous. This seems to work well in practice, though whether the differences observed represent a true change in the nature of the sedimentation, or merely reflect variations in the local conditions of metamorphism, is still uncertain.

Numerous occurrences of banded grünerite-quartzite were noted. Where weathered these are sometimes strongly manganiferous. They usually occur close to the margin of the Bengpals and the orthogneisses.

102. Dr. P. K. Ghosh completed the mapping of the boundaries of the Cuddapah outlier, discovered by him during the previous field-season, on the one-inch sheet 65 F/10, Bastar State, and also subdivided and mapped the different members of the Cuddapahs occurring in this basin.

Bastar State.

According to him, the area under investigation was subjected to at least two compressional movements, *viz.*, an earlier one, which affected the country during post-Archæan but pre-Cuddapah times, operating from the south-west, and a later one, post-Cuddapah in age, but operating from the south-east. He also observes that the Archæans during the former period of compression yielded mainly by flowage and folding; whereas at the time of the subsequent disturbance, they behaved as a fairly rigid mass and readjusted themselves to the new conditions by essentially vertical movements along planes of fracture. The Cuddapahs, forming as they do but a thin covering on the underlying Archæans, while generally sharing in these vertical movements, show in places, particularly near the marginal regions of the basins, the usual signs of disturbances produced by lateral compression, *viz.*, folding, crumpling and schistosity.

103. During February, March and the first week of April, Mr. W. D. West continued the detailed mapping of the Sausar series on sheet 55 O/6, in the Nagpur and Chhindwara districts. The work was confined mainly to the north-west quarter of the sheet.

Nagpur and Chhindwara districts, C. P.

The mapping of the north-west end of the Deolapar *nappe* was first completed. While it is quite clear that this end of the *nappe* pitches north-west into the air, the exact manner in which it finishes is difficult to determine, owing to abundant intrusions of granite and pegmatite, which have replaced the sedimentary succession.

To the north of this *nappe* is a large area of orthogneisses. In the midst of these gneisses a band of the Sausar series was unexpectedly found extending from one mile south of hill 1652 (21° 40′: 79° 16′) for about two and a half miles in an east by south direction, where it finally thins out in the orthogneisses and pegmatites. It consists of the Kadbikhera, Utekata and Lohangi stages. It is possible that certain traces of the latter two stages, which had been found during the previous field season within the orthogneisses further south-east, are relics of this band. The band is to be regarded as a remnant of the northern limb of an anticline, the southern limb of which runs through Kadbikhera (21° 37′: 79° 21′).

In the north-west corner of the sheet, the rocks consist in the main of pink and grey orthogneisses, with thin bands of the Bichua (dolomitic marbles) and Chorbaoli (quartzites) stages. Associated with the pink gneisses there occur abundant dykes of pink aplite, and the two are clearly genetically related. This association of massive pink orthogneisses and aplites in the northern half of the sheet may be contrasted with the association of streaky orthogneisses and pegmatite dykes in the southern half of the sheet.

In the extreme north-west corner of the sheet the higher hills are capped with a flow of Deccan trap, overlain by laterite. The base of the trap is at 1,830 feet. One or two dykes of trap occur to the east of this flow on the lower ground.

At about a mile north-east of Khawasa (21° 42′ : 79° 26′) a thin bed of sillimanite-quartz-schist was traced for about a mile and a half along the strike. Since it occurs in the midst of orthogneisses, its horizon in the Sausar series is not known. Although in places it is almost pure sillimanite, for the most part the quartz is too abundant for the bed to be of economic value.

The completion of the detailed mapping of this sheet, which has mostly been done on the scale of four inches to one mile, is now within sight, and only about six or seven weeks work remains to be done. The mapping has necessarily been slow, since the stages of the Sausar series are often thin and impersistent, the jungle is thick, and the alluvium and soil cap, which obscure so much of the softer members of the series, has had to be mapped separately. It is difficult to see how mapping under such conditions, if it is to be of any real value, can be expedited, but it is hoped that when this sheet has been completed, the detailed knowledge thus gained may, with judicious grouping of certain stages, enable the adjacent country to be mapped at greater speed, though necessarily in less detail.

Bhandara district and Nandgaon and Khairagarh States, C. P.

104. Mr. D. Bhattacharji continued his systematic mapping in the Bhandara district and in the feudatory States of Nandgaon and Khairagarh. He completed the southern portion of the sheet 64 C/8, the whole of the sheet 64 C/12 with the exception of small areas near the north-west and south-east corners, the north-western half of sheet 64 C/16 and small portions of sheets 64 C/11 and 64 C/15. A large portion of the ground had not been mapped previously, while the

rest was rather roughly surveyed by P. N. Datta in 1904-7 and W. King[1] in 1883-5.

Mr. Bhattacharji draws attention to the following features in regard to the area examined by him in the Bhandara and adjacent areas :—

(A) The trend of the rocks in the surrounding regions—

(1) the strike of the rocks in the Eastern Ghats, *etc.*;

(2) the grain of the rocks down the Godaveri; and

(3) the foliation of the rocks in the Satpuras.

These rocks are disposed roughly on three sides of a triangle, the central triangular area being Bhandara.

(B) Within the main Bhandara triangle there is abundant field evidence that the main structural features—

(1) lines of quartz veins;

(2) direction of foliation; or

(3) disposal of intrusions,

are roughly parallel with the trend lines of the areas enclosing Bhandara—*i.e.*, they have three chief directions—(1) roughly N.-S.: (2) generally W. N. W. and (3) approximately E. N. E. In short the rocks of Bhandara have, in a horizontal plane, three cleavages or foliation directions roughly at 60° to each other and these have given rise to smaller triangular structural areas.

(C) Almost every hand specimen of rock within Bhandara when either macroscopically or microscopically studied reveals this triangular aspect of structures—

(1) the arrangement of the minerals is along three main directions roughly at 60° for foliated rocks; or

(2) similarly disposed in those rocks which are recrystallised.

From these observations Mr. Bhattacharji draws several conclusions, the most important of which are—

I. That the pressures which induced the orographic axes in the Eastern Ghats, the Satpuras and the Godaveri valley, have affected the rocks in Bhandara even down to their microscopic texture.

II. That these pressures have affected the rocks in three ways :—(*a*) producing, dynamically, cleavage by mylonitisation generally and (*b*) foliation as distinct from mylo-

[1] *Rec. Geol. Surv. Ind.*, XVIII, Pt. 4, pp. 169-172, (1885).

nitisation, and (*c*) by inducing crystallisation or secondary crystallisation where static pressures appear to have prevailed.

III. That II (*a*) probably indicates conditions under which the rocks have been sheared (mylonitised) or II (*b*) rendered plastic; in the former cases the rocks were not so deeply buried as in the latter, other things being equal; and that in case II (*c*) the rocks were subject to so great a static pressure, and were possibly under high temperature in consequence, that complete crystallisation has taken place and secondary granitic rocks have been produced.

Mr. Bhattacharji's observations, thus briefly stated, can be considered as data in support of the well-known ideas of Grubenmann and others of the recognition of different zones in Van Hise's zone of anamorphism where rocks may be strong enough to be (*a*) mechanically sheared or mylonitised; or at a lower depth or under greater strain the rocks (*b*) may be rendered plastic and so intensely folded and distorted; or at still greater depth or far greater pressures the rocks (*c*) may recrystallise or develop entirely new minerals characteristic of this zone.

For the purposes of mapping, the old method of classification has been generally followed. According to this, the rocks mapped are—(1) alluvium, (2) the Cuddapahs and/or the Vindhyans, (3) the Sakolis, (4) the Sausars, (5) the mylonites and cataclasites, (6) the granulites and the fine-grained gneisses and schists, (7) the coarse-grained gneisses and schists and the gneissic granites and (8) the granites (apparently very slightly altered).

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THE DYKE ROCKS OF KEONJHAR STATE, BIHAR AND ORISSA.

BY M. S. KRISHNAN, M.A., PH.D., A.R.C.S., D.I.C., *Assistant Superintendent, Geological Survey of India.*

(With Plate 1.)

CONTENTS.

INTRODUCTION.

The area from which the material under description was collected is in the northern part of Keonjhar State, Bihar and Orissa, comprised in the Survey of India sheet 73 G/9. It is included in the map accompanying the memoir on the iron-ores of Bihar and Orissa by Mr. H. Cecil Jones.[1] The whole of the area in question, excepting a fringe of sandstone of the Iron-ore series along the western margin, is covered by granite which is traversed by a system of very numerous dykes.

The granite is part of a batholithic mass extending into and occupying a large tract of country in the adjoining districts of Singhbhum and Mayurbhanj. It is apparently of uniform composition throughout the area, being composed of quartz, orthoclase, microcline and oligoclase with very subordinate muscovite and biotite.

[1] *Mem. Geol. Surv. Ind.*, LXIII, Pt. 2, (1934).

Petrographically it is very similar to the granites found in Singhbhum, Ranchi, Bonai, etc., described recently by Dr. J. A. Dunn[1] and Dr. L. A. Narayana Iyer.[2] In the area under consideration the dykes are intrusive into the granite, and all, except one, are basic in character. The dykes are mostly doleritic in texture, but some are basaltic, while gabbro or norite has also been observed in a few places [*e.g.*, in the dykes near Durgapur (21° 51′ : 85° 36′); Palasponga (21° 47′ : 85° 34′); Kanchan Dumaria (21° 50′ : 85° 42′); and Burduma Huri (21° 48′ : 85° 44′)]. The single exception to the universal basic nature of the dykes is one which is sub-acid in composition and is mainly of the nature of an epidotised augite-granophyre.

In the following pages are described the petrographic and chemical characters of these dyke rocks. The chemical analyses were done by Mr. P. C. Roy, Assistant Curator of this Department, to whom my thanks are due for the trouble he has taken. The analysis of the norite (specimen No. 36/520 in the collections of the Geological Survey of India) which shows unusually low alumina and lime and high magnesia, was completely repeated. The second analysis, however, agreed very closely with the first, dispelling the doubts entertained about the accuracy of the first and confirming the noritic nature of the rock.

DESCRIPTION OF THE DYKE ROCKS.

Dolerite and Basalt.

The basic rocks vary from very fine-grained ones breaking with a sub-conchoidal fracture, to those with medium grain. Coarse types are distinctly rare. The colour is generally grey, with a fairly well-marked greenish tinge. The specific gravity, determined on some twenty-five representative specimens collected by me from various localities in the area, shows values ranging between 2·89 and 3·22 with an average of 2·976 (27° to 30° C.). The dykes vary in thickness individually and severally, from a few feet to as much as 700 yards.

A computation was made of the length of the dykes in relation to the directions followed by them. The aggregate lengths, averaged

[1] *Mem. Geol. Surv. Ind.*, LIV, (1929).
[2] *Rec. Geol. Surv. Ind.*, LXV, pp. 490-533, (1932).

mostly for intervals of every 10 degrees of the compass, are shown below :—

Direction.	Aggregate length.
	Miles.
330°	6·6
340°	17·0
350°	5·0
360°	28·0
10°	33·2
20°	65·2
30°	97·4
45°	10·6
65°	10·5

A glance at the map in the memoir by Mr. Jones will show that the direction most favoured by the dykes is near about 30° (N. 30° E.) while a subsidiary one around 340° (N. 20° W.) can also be recognised. These two correspond to the major directions of joints in the granite.

The rocks are composed mainly of augite and plagioclase, the relationship between the two being sub-ophitic. Porphyritic crystals, either of augite (*e.g.*, 36/492, 36/541)[1] or of felspar (36/529), are occasionally seen. The felspars frequently show a pale greenish tint, this being due, at least partly, to the development of microscopic secondary products like epidote and chlorite in them. They are generally altered to various degrees, the alteration products including kaolin, sericite, calcite, chlorite and epidote. The fresh mineral shows lamellar twinning from which the composition has been deduced as andesine-labradorite or acid labradorite. The augite is usually fresh and colourless, but rarely showing just a suggestion of greenish tinge. Twinning on *a* (100) is common and 'herringbone' structure is sometimes seen. It alters to uralite and chlorite, and in a smaller degree to epidote and rarely to serpentine (36/537).

An almost constant feature in the basic rocks is the presence of a little quartz and micropegmatite. In some cases the quartz forms comparatively large, megascopic blebs (36/496). The micropegmatite often surrounds the felspars in radiating fashion. The minor minerals include titano-magnetite or ilmenite with the leucoxene derived from them, and pyrite. Distinct interstitial groundmass is frequently observed, which may be finely micrographic

[1] Registered numbers in the rock collection of the Geological Survey of India, Calcutta.

or altered glassy material. Amygdales are uncommon, those found in specimen 35/416 being usually 2 to 3 mm. and rarely, 8 mm. across.

Two rocks, a very fine-grained basalt (35/403) and a quartz-dolerite (36/496), were analysed. The results are given in Table 1 together with the analyses of some other types of Indian traps for comparison.

TABLE 1.—*Analyses of Dolerites and Basalts.*

—	1 35/403	2 36/496	A Average Newer Dolerite.	B Average Gwalior Trap.	C Average Deccan Trap.	D Average Cuddapah Trap.	E Augite-diorite, Seven Pagodas, Madras.
SiO_2	49·85	53·96	52·25	50·18	50·61	48·34	51·15
TiO_2	1·20	trace	0·94	1·59	1·91	1·66	0·44
Al_2O_3	15·80	13·13	14·28	11·73	13·58	12·76	15·92
Fe_2O_3	0·23	0·98	1·90	2·02	3·19	3·39	9·34
FeO	11·60	8·58	9·85	11·94	9·92	11·76	2·87
MnO	0·24	0·10	0·19	0·50	0·16	0·76	0·09
MgO	5·60	7·26	5·27	5·45	5·46	5·84	6·48
CaO	10·02	9·07	8·39	10·05	9·45	10·13	10·40
Na_2O	2·78	3·71	2·79	4·47	2·60	2·56	1·19
K_2O	0·94	0·30	1·50	0·95	0·72	0·44	1·61
H_2O+	1·58	2·56	2·09	0·61	1·70	2·38	0·11
H_2O-	0·22	0·25	0·13	0·20	0·43	0·28	
P_2O_5	0·16	0·15	0·30	0·74	0·39	0·10	0·06
S	0·09	0·06	0·04	..	..	..	..
CO_2	0·16	0·26	0·12	..	..	..	..
TOTAL	100·47	100·37	100·04	100·43	100·12	100·40	99·66
Sp. Gr.	3·067	2·942	2·983	2·98	2·916	3·106	2·96

Niggli Values.

—	1	2	A	B	C	D	E	F	G
Si . .	119·4	134·8	134·9	117·6	126·3	114·1	122·2	135	108
Al . .	22·3	19·3	21·7	16·2	20·0	17·8	22·4	24·5	21
Fm . .	44·1	47·0	45·6	47·0	47·4	50·5	45·8	42·5	52
C . .	25·7	24·3	23·2	25·2	25·3	25·3	26·6	23	21
Alk . .	7·9	9·5	9·4	11·6	7·4	6·5	5·2	10	6
Mg . .	·45	·58	·44	·40	·43	·39	·50	·50	·55
C/Fm .	·58	·52	·51	·54	·53	·51	·58	·54	·40
K . .	·18	·05	·27	·12	·15	·10	·47	·28	·20
Ti . .	2·16	..	1·83	2·80	3·58	2·96	0·79	..	..
P . .	0·16	0·16	0·33	0·73	0·42	0·13	0·06	..	..
Qz . .	—12·1	—3·1	—2·9	—28·8	—3·4	—11·9	+1·4	—5	—16

1. Very fine-grained basalt (35/403) from a dyke half a mile north of Giridharpur (22° 0′ 30″ : 85° 35′), Keonjhar State. Anal. P. C. Roy.
2. Quartz-dolerite (36/496) from a dyke three furlongs south-east of Giridharpur, alongside the path to Jamjori, Keonjhar State. Anal. P. C. Roy.
A. Average composition of three 'Newer Dolerites' of Singhbhum. *Rec. Geol. Surv. Ind.*, LXV, p. 528, (1932). Anal. L. A. Narayana Iyer.
B. Average composition of six 'Gwalior traps'. *Jour. Geol.*, XLIII, p. 69, (1935). Anal. M. P. Bajpai. (Analysis as revised by the author.)
C. Average composition of eleven 'Deccan traps'. *Bull. Geol. Soc. Amer.*, XXXIII, p. 774, (1922). Anal. H. S. Washington. One of these eleven is from the Rajmahal, not Deccan trap.
D. Average composition of two 'Cuddapah traps'. *Mem. Geol. Surv. Ind.*, LXIV, Pt. 2, pp. 224-225, (1934). Anal. P. C. Roy and Mahadeo Ram.
E. Augite-diorite (or diabase) from a dyke at Seven Pagodas, Chingleput district, Madras. T. H. Holland, *Rec. Geol. Surv. Ind.*, XXX, p. 35, (1897). Anal. P. Brühl.
F. Niggli's gabbro-diorite type. P. Niggli and P. J. Beger. 'Gesteins und Mineral provinzen', p. 126, Berlin, (1923).
G. Niggli's normal gabbro-norite type. *Ibid.*, p. 128.

It will be seen from Table 1 that the average Singhbhum dolerite occupies a position between the Keonjhar dolerite and basalt. This close relationship is of course to be expected, since the dykes in Keonjhar are simply a continuation of the 'Newer Dolerite' dykes in Singhbhum. The average Deccan trap is also akin to these dyke rocks. In comparison with these, the Gwalior trap contains less alumina and more alkalies, and shows a greater deficiency of silica in the Niggli values. The 'augite-diorite' containing micro-pegmatite, which has been described by Sir T. H. Holland, also shows a good deal of resemblance (it would appear that in the analysis, as reported, the FeO and Fe_2O_3 have been interchanged). In the table of Niggli values, those for Niggli's gabbro-diorite and gabbro-norite types are given for comparison, the first being more acid and the second being more basic than the above-mentioned traps.

Norite.

Just east of Durgapur (21° 51′ : 85° 36′) is a broad dyke from the centre of which the specimen 36/520 was collected. The rock is dark grey in colour, the pyroxenes showing a bronzy lustre. Under the microscope it is found to consist of dominant pyroxene which is here and there altered to serpentine. The basic plagioclase is to a large extent altered. Some ilmenite and leucoxene, a little quartz, micropegmatite and a few flakes of biotite are also seen. The modal composition determined by means of a Wentworth recording micrometer, is 77 per cent. pyroxene, 18 per cent. felspar, 4 per cent. micropegmatite and quartz, and less than 1 per cent. iron ores and biotite.

The pyroxenes are colourless and non-pleochroic. Several of them give straight extinction and rather low interference colours and are referable to the orthorhombic group. The others give oblique extinction and higher interference colours and are therefore monoclinic. The optic axial angle, which was determined for a few, ranges between 20° and 40°. Hence the monoclinic pyroxenes seem to belong to the enstatite-augite (pigeonite) group.

In Table 2 are given the analyses of the rock from the dyke near Durgapur and of some other related types. The perknite from Singhbhum, analysed by L. A. N. Iyer, is included since it also

represents a coarse differentiate from similar basic dykes (Newer Dolerite) in an adjoining area.

TABLE 2.—*Analyses of Norite and Related Types.*

—	3 (36/520).	H Augito-norite, Eriyur.	I Hypersthenite, Pallavaram.	J Perknite, Singhbhum.
SiO_2 . . .	53·82	53·05	46·86	52·59
TiO_2 . . .	0·33	1·77	..	0·30
Al_2O_3 . . .	8·07	8·91	9·80	3·69
Fe_2O_3 . . .	2·11	3·26 }	16·35	{ 2·63
FeO . . .	7·00	9·52 }		{ 8·36
MnO . . .	0·21	0·09	..	0·22
MgO . . .	18·39	14·42	18·08	19·38
CaO . . .	5·96	6·76	9·57	11·49
Na_2O . . .	1·28	0·66 }	trace	{ ..
K_2O . . .	0·82	0·48 }		{ 0·22
H_2O+ . .	1·57 }	0·65	0·67	{ ..
H_2O- . .	0·08 }			{ 0·58
P_2O_5 . . .	0·04	0·09	..	0·13
CO_2 . . .	0·05	..	..	0·14
TOTAL .	99·73	99·66	101·33	*100·10
Sp. Gr. . . .	3·095	3·09	3·333	3·34

* Includes Cr_2O_3, 0·22, NiO, 0·09 and S, 0·06.

Niggli Values.

—	3	H	I	J	K
Si . . .	112·3	116·9	84·8	99·4	80
Al . . .	9·9	11·6	10·5	4·1	10
Fm . . .	73·1	70·4	71·0	72·4	74
C . . .	13·3	15·9	18·5	23·3	14
Alk . . .	3·7	2·1	..	0·3	2
Mg . . .	·78	·67	·69	·75	·72
C/Fm . .	·18	·23	·26	·32	·19
K . . .	·30	·32	..	1·00	..
Ti . . .	0·51	2·94	..	0·43	..
P . . .	0·04	0·08	..	0·10	..
Qz . . .	—2·4	+8·5	—15	—1·6	—28

3. Coarse norite (36/520) containing much magnesian pyroxene, subordinate felspar, interstitial quartz and micropegmatite and a little iron-ore and biotite; from the central part of the dyke east of Durgapur, Keonjhar State. Anal. P. C. Roy.

H. Augite-norite; hemicrystalline, with small phenocrysts of enstatite, the groundmass containing minute augites wrapped around by tufted microlites of felspar and interstitial glass; from Eriyur, South Arcot district, Madras Presidency. T. H. Holland, *Rec. Geol. Surv. Ind.*, XXX, p. 28, (1897). Anal. P. Brühl.

I. Hypersthenite from Pallavaram near Madras, containing much schillerised hypersthene, brown hornblende and augite, a little olivine, spinellids and occasional apatite. T. H. Holland, *Mem. Geol. Surv. Ind.*, XXVIII, Pt. 2, p. 166, (1900). Anal. T. L. Walker.

J. Perknite (34/457) associated with dolerite, from a dyke one mile east of Belma, Singhbhum district. Contains much augite set in a fine-grained groundmass of augite, a little felspar, quartz, biotite and calcite. L. A. N. Iyer, *Rec. Geol. Surv. Ind.*, LXV, p. 528, (1932). Anal. L. A. N. Iyer.

K. Niggli's hornblendite-pyroxenite-peridotite type ' (Niggli and Beger, ' Gesteins und Mineral provinzen ', p. 136, Berlin, (1923).

The norite from Durgapur, the analysis of which is given in the above Table 2, is seen to be unusually rich in magnesia, which is accounted for by the character of the pyroxene. Its occurrence in the central portion of a dolerite dyke and its gradation into the latter type of rock show clearly that it is a product of differentiation, probably through the segregation of earlier formed crystals. In the table are given also the analyses of an augite-norite and a hypersthenite, both from South India, which show a fairly close similarity to the

rock from Keonjhar. This norite is therefore a type related to hypersthenites and picrites. It differs from ordinary pyroxenites and hornblendites in containing more magnesia and less alumina and lime, and from ordinary peridotites in containing more silica, alumina and lime and less magnesia. It thus falls between these two general groups, and resembles Niggli's hornblendite-pyroxenite-peridotite magma type except for the greater proportion of silica. The perknite described by Dr. L. A. N. Iyer, although very similarly related to the same system of basic dykes, is a type distinctly richer in lime, due evidently to the pyroxene being diopsidic, as shown by the large optic axial angle (56°—60°, and 68°).

The optical characters of the pyroxene and the bulk composition of the norite show that the pyroxene is a magnesia-rich variety. For understanding the chemical nature of the mineral, the rock was crushed to pass an 80-mesh sieve and the pyroxene separated by means of Sonstadt solution (potassium mercuric iodide) of density 3·1. On analysis, the following result was obtained:—

TABLE 3.—*Analysis of Pyroxene.*

	Per cent.
SiO_2	53·96
TiO_2	0·43
Al_2O_3	2·63
Fe_2O_3	3·65
FeO	7·56
MnO	0·28
MgO	24·78
CaO	6·10
Alkalies	trace
P_2O_5	*Nil*
TOTAL	99·39*

* (H_2O less than 0·1 per cent.) Analyst: P. C. Roy.

For comparing the relative abundance of the oxides of iron, magnesium and calcium in the pyroxene with that in the rock, the molecular proportions of the three oxides have been recalculated to

100, all the iron being reckoned as ferrous. The values are given below :—

—	FeO.	MgO.	CaO.	MgO/FeO.	MgO/CaO.
Pyroxene	17·27	70·29	12·44	4·1	5·6
Rock (norite) . . .	18·04	66·47	15·49	3·7	4·3

Some work has already been accomplished by several investigators in studying the composition of the pyroxenes in relation to that of the rocks in which they occur. Fenner[1] has found that there is a higher MgO : FeO ratio in the pyroxene than in the rock, this accounting for the elimination of iron at a late stage in the form of magnetite. Wahl[2] and Washington[3] have shown that magnesia-rich enstatite-augite is characteristic of the plateau-basalt type of basic rocks, while lime-rich diopsidic augite is characteristic of olivine-diabase and 'cone-basalt'. Fermor[4] and Barth[5] have however expressed the view that enstatite-augite is the common pyroxene of all basaltic rocks[6]. This question is discussed in a recent paper by Kennedy[7] who supports Wahl's and Washington's views. In the present case there is no doubt that the pyroxene is enstatite-augite, showing a higher MgO : CaO ratio than the rock in which it occurs, and that the rock belongs to the plateau-basaltic or tholeiitic type.

The Sub-acid Dyke.

There is a conspicuous dyke of grano-dioritic composition which extends from Khuntapoda (21° 52′ : 85° 36′ 30″) in a N. 20° E. direction to Sosang (22° 1′ : 85° 40′). Its length is about ten miles

[1] C. N. Fenner. The crystallisation of basalts. *Amer. Jour. Sci.*, XVIII, pp. 225-253, (1929).

[2] W. Wahl, Die Enstatitaugite. *Min. Petr. Mitt.*, XXVI, p. 14, (1907).

[3] H. S. Washington. Deccan traps and other plateau basalts. *Bull. Geol. Soc. Amer.*, XXXIII, p. 800, (1922).

[4] L. L. Fermor. Enstatite-augite series of pyroxenes. *Rec. Geol. Surv. Ind.*, LVIII, p. 323, (1926).

[5] T. Barth. *Amer. Mineral.*, XVI, p. 196, (1931).

[6] My remarks, *loc. cit.*, referred to the plateau-basalt type only and my conclusion that the pyroxenes of the enstatite-augite series are probably the most abundant pyroxenes in nature is based on the assumption that the plateau-basalts are volumetrically much more important than the cone-basalts, at least in the rocks exposed at the surface.—L. L. F.

[7] W. Q. Kennedy. Trends of differentiation in basaltic magmas. *Amer. Jour. Sci.*, XXV, pp. 250 254, (1933).

while its maximum thickness is over 600 yards. The rock of which it is made up is medium-grained, light greenish grey, and sometimes mottled with pink. The greenish colour is imparted by epidote, of which a variable amount is almost always present. The specific gravity of the rock ranges between 2·75 and 3·15, with a mean of 2·90. Those giving high values are always rich in epidote.

From this dyke two specimens were selected for analysis. The specimen 36/501 from near Gumaria (21° 59′ : 85° 39′), which represents an average type, is composed to a large extent of micropegmatite in which patches of quartz can be recognised. Some twinned crystals of plagioclase can also be seen. There is some undoubted augite as well as a fair amount of epidote, the latter derived, at least in part, from the former. Some titano-magnetite and leucoxene and a little calcite are also present.

Specimen 36/502, which was collected from the marginal portion of the same dyke just west of where it is cut through by a stream south of Hastinapur (21° 57′ : 85° 38′), looks partly fine-grained and partly glassy and possesses a marked light green colour. Microscopic examination shows that it is composed of micropegmatite and aggregates of green epidote. Some grains of leucoxene are interspersed among the other minerals.

The mineral composition of this dyke shows that the rock may be called an epidotised (augite) granophyre. Other specimens from the same dyke (36/499, 500, 508, 516 and 541) are of the same nature. The felspar includes both plagioclase (oligoclase-andesine or andesine) and orthoclase, the latter mostly intergrown with quartz. The augite is somewhat schillerised and often replaced by epidote, amphibole or even chlorite. Small amounts of ilmenite or leucoxene and rare pyrite are also present. The analyses of the two specimens described above are given in Table 4.

Though both the rocks (36/501 and 36/502) were collected from the same dyke, there are differences in mineral composition which are reflected in the analyses. The latter is poorer in silica and alkalies and richer in ferric iron and lime, in comparison with the former. The former resembles some segregation veins associated genetically with quartz-dolerites, as will be seen from analysis (L) in the Table. The other contains much epidote and resembles, roughly, an epidotised quartz-diallage-syenite, the analysis of which (M) is also given for comparison.

TABLE 4.—*Analyses of Sub-acid Rocks.*

	4	L	5	M		Niggli Values.			
	36/501.	36/502.				4	L	5	M
SiO_2 .	67·41	69·36	58·91	58·32	Si .	286·7	321·1	178·0	193·9
TiO_2 .	0·83	trace	0·78	..	Al .	31·2	28·7	25·7	29·2
Al_2O_3 .	12·45	10·53	14·42	15·77	Fm .	28·9	28·3	21·8	21·7
Fe_2O_3 .	3·77	2·99	7·42	6·56	C .	17·3	17·7	48·2	41·6
FeO .	3·33	3·03	1·13	0·89	Alk .	22·6	25·2	4·4	9·5
MnO .	0·32	..	0·07	0·13	Mg .	·13	·22	·09	·02
MgO .	0·61	0·90	0·41	0·09	C/Fm	·60	·63	2·21	1·92
CaO .	3·81	3·57	14·89	11·68	K .	·35	·37	·08	·89
Na_2O .	3·54	3·56	1·38	0·32	Ti .	2·66	..	1·78	..
K_2O .	2·94	3·15	0·18	4·01	P .	0·38	0·44	0·16	0·68
H_2O+	1·00	1·46	0·83	1·73	Qz .	+96·5	+120·1	+60·4	+55·7
H_2O-	0·07	..	0·02						
P_2O_5 .	0·21	0·22	0·13	0·48					
CO_2 .	0·24	2·07	*Nil*	..					
S .	*Nil*	..	*Nil*	..					
TOTAL .	100·53	100·84	100·57	99·98					
Sp. Gr.	2·76	2·60	3·12	..					

4. From the dyke one mile south of Gumaria, Keonjhar State. Anal. P. C. Roy.

5. From the same dyke, just west of the intersection with the stream south of Hastinapur. Anal. P. C. Roy.

L. Segregation vein associated with quartz-dolerite near Hound Point, Dalmeny, Scotland. T. C. Day. Chemical analyses of quartz-dolerites and segregation veins at Hound Point, North Queensferry and Inverkeithing. *Trans. Edin. Geol. Soc.*, XII, p. 85, (1928). Anal. T. C. Day.

M. Unakite from Milam's Gap, Virginia, U. S. A., consisting of orthoclase and green epidote with some quartz, iron-ores, zircon, and apatite, derived from a hypersthene-akerite or quartz-diallage-syenite. F. W. Clarke. Data of Geochemistry, *U. S. Geol. Surv., Bull.* 770, pp. 609-610, (1924). Anal. W. C. Phalen.

AGE OF THE ROCKS.

As already mentioned, the granite of the area is part of a batholith extending from here into the neighbouring districts and it can be definitely regarded as the accompaniment of the orogenic revolution at the close of the Dharwarian era. The dolerite is intrusive into and later than the granite, but no idea can be gained of the time interval which separated the intrusion of the two types. In Peninsular India there are trappean rocks intrusive into part of the Cheyairs (Cuddapahs), and the Delhis, which have all been considered to be of pre-Cambrian age but later than the Dharwars. The next younger group of basic rocks appears only in Rajmahal (Jurassic) times and this may be considered as an earlier phase of the Deccan traps.[1] So far as known, there are no basic rocks in Peninsular India to represent any part of the enormous gap of time between the two.

The dyke rocks of Keonjhar are probably of about the same age as the Cuddapah traps. In contrast with the basic rocks of an earlier age, which are all completely amphibolised or converted into epidiorite, these have been only slightly altered or are often fresh. All these again are characterised by the general presence of micropegmatite in the matrix.

Field evidence is not very clear as to the age of the sub-acid dyke. A single thin dyke of basalt intersects it but the contact is obscured by soil and debris. The indications are however that it is semi-contemporaneous with, or slightly younger than, the basic dykes.

ORIGIN OF THE MICROPEGMATITE.

The acid material in the basic dykes is in the form of micropegmatite, free quartz or acid glass. It is generally found in the interstitial groundmass, but may also form megascopic patches.

With regard to the presence of the micropegmatite in basic rocks, two alternative hypotheses may be considered: firstly that it is due to the solution of acid or granitic rock by hot basic magma prior to or during intrusion, and secondly that it is the residual product of differentiation of the basic magma itself. In the first case it is due to extraneous assimilated matter and in the second it is a direct derivative of the rock in which it is found.

[1] C. S. Fox, *Current Science*, III, p. 428, (1935).

With regard to the first hypothesis, it is well known from actual field observations that basic and acid rocks can mix and produce a hybrid or intermediate product. In the present case it is manifest that the dykes have penetrated through and are surrounded by granitic rocks, and hence such a mixing may probably have taken place. Dr. N. L. Bowen[1] has discussed this question and has stated that such assimilation can take place if the rock dissolved belongs to the same reaction series as the basic rock dissolving it, though quantitatively it may not be of much importance. The margins of the basic dykes against the granite are, wherever they can be seen, quite sharp, so that any such assimilation must have taken place at depth and probably in and around the magma chamber.

With regard to the second alternative it may be noted that the residual acid material is present in many basic rocks in India and elsewhere. In the basic dykes in Keonjhar there is a variable, though generally small, amount of micropegmatite and quartz, but in the sub-acid dyke the micropegmatite forms the major portion of the rock. Sir T. H. Holland has discussed the origin of such material occurring in the basic dykes in the Madras Presidency as early as 1897. He wrote :[2]

'I would consequently prefer the explanation I have already given, namely that the micropegmatite is really original, the last phase in the consolidation of the rock, and its formation and preservation are facilitated by the perfectly quiet conditions of consolidation and subsequent freedom from dynamic disturbances.'

Again,[3]

'Even distinct veins of granophyre, instead of being considered normal igneous intrusions, can best be explained as " contemporaneous veins " formed as the final stage in the consolidation of the magma from which the augite-diorite was obtained during the earlier stages of its consolidation. When consolidation takes place under limited pressure as was probably the case with the Madras dykes, the framework of augite and plagioclase will be sufficiently strong to prevent collapse, and the micropegmatite can thus consolidate in the intercrystal cavities. But where the pressure is in excess of that which the framework of augite and plagioclase is able to withstand, as is more likely to be the case in large masses, the mother liquor will be squeezed out and will consolidate as a separate mass of granophyre. Some such explanation as this I would offer to account for the frequent association of masses of augite-diorite (gabbro) with granophyre ; or in other words, to account

[1] Evolution of Igneous rocks, pp. 199-201, Princeton University Press, (1928).

[2] T. H. Holland. On some norite and associated basic dykes and lava flows in Southern India. *Rec. Geol. Surv. Ind.*, XXX, p. 34, (1897).

[3] *Ibid.*, p. 39.

for the separation of these genetically related rocks when the magma is sufficient to form large bosses, and for their intimate microscopic association where the magma consolidates in narrow dykes.'

Bowen[1] considers that quartz or acid residue in basic rocks results from the early separation of olivine from the crystallising magma in excess of its actual stoichiometric proportion. Fenner[2] however points out that though experimentally sound, this is not supported by the field evidence of the rocks. In a recent contribution to the study of the differentiation of basaltic rocks, W. Q. Kennedy[3] concludes that there are two fundamentally different types of basaltic magmas, one tholeiitic and the other olivine-basaltic. The tholeiitic magma, represented predominantly among the plateau basalts, gives rise, according to him, to an acid differentiate of which quartz, acid plagioclase, micropegmatite and common augite are characteristic; the olivine-basalt type (oceanic basalts) results in products which contain abundant potash and soda felspars, felspathoids, soda pyroxenes, titanaugite and amphiboles, but no quartz. The rocks described here will fall under the normal tholeiitic types and their derivatives and are therefore not in any sense peculiar. As shown above, the nature of the pyroxene also supports this conclusion. Moreover, these rocks could not have any particular significance with regard either to space or geological time, since they are to be found associated with fissure as well as central eruptions in many parts of the world and in various geological ages.

The rocks under study belong therefore to the tholeiite group, the granophyric dyke apparently representing a late differentiate or pegmatoid. It is impossible to evaluate the part played by assimilated acid material. In the present state of our knowledge of the physical chemistry of the differentiation processes in basic rocks, no clear distinction between the products of normal differentiation and those due to assimilation of extraneous acid material seems possible. The relative importance of the role played by these two processes must remain vague and unsettled until some definite criteria can be established, particularly through experimental work.

[1] N. L. Bowen, *loc. cit.*, pp. 70-74.

[2] C. N. Fenner. The crystallisation of basalts. *Amer. Jour. Sci.*, XVIII, pp. 225-253, (1929). The residual liquids of crystallizing magmas. *Mineral Mag.*, XXII, pp. 539-560, (1931).

[3] W. Q. Kennedy. 'Trends of differentiation in basaltic magmas'. *Amer. Jour. Sci.*, XXV, pp. 239-256, (1933).

EXPLANATION OF PLATE.

PLATE 1. FIG. 1.—Dolerite (36/507 : 17472) from a dyke near Kasia, Keonjhar State. Ordinary light, × 24.

FIG. 2.—Granophyre (36/502 : 17468) from the dyke near the intersection of the stream south of Hastinapur. Polarised light, × 24.

FIG. 3.—Granophyre with epidote (36/501 : 17467) from the dyke one mile south of Gumaria. Polarised light, × 24.

FIG. 4.—Norite (36/520 : 17486) from the dyke just east of Durgapur. Ordinary light, × 24.

MISCELLANEOUS NOTE.

Quarterly Statistics of Production of Coal, Gold and Petroleum in India : October to December, 1935.

Coal.

—	October.	November.	December.	Quarterly total for each Province.
	Tons.	Tons.	Tons.	Tons.
Assam	15,795	19,933	17,607	53,335
Baluchistan	71	940	267	1,278
Bengal	523,858	562,179	589,384	1,675,421
Bihar and Orissa	985,115	985,188	1,051,854	3,022,157
Central Provinces	119,874	123,265	133,496	376,635
Punjab	15,962	18,228	14,287	48,477
TOTAL	1,660,675	1,709,733	1,806,895	5,177,303

Gold.

—	October.	November.	December.	Quarterly total for each Company.
	Ozs.	Ozs.	Ozs.	Ozs.
The Mysore Gold Mining Co., Ltd.	8,040	7,981	8,235	24,256
The Champion Reef Gold Mines of India, Ltd.	5,778	5,590	5,775	17,143
The Ooregum Gold Mining Company of India, Ltd.	4,796	4,434	4,334	13,564
The Nundydroog Mines Ltd.	9,227	9,231	9,257	27,715
TOTAL	27,841	27,236	27,601	82,678

Petroleum.

—	Crude petroleum.	Total gasolene from natural gas.*
	Gallons.	Gallons.
Assam	17,242,494	*Nil*
Burma	61,066,858	2,371,377
Punjab	1,540,240	109,479
TOTAL	79,849,592	2,480,856

* These figures represent the total amounts of gasolene derived from natural gas at the well-head. Of these amounts, a portion is sold locally as 'petrol' and the remainder is mixed with the crude petroleum and sent to the refineries. The figures given in the two columns, therefore, together represent the total 'raw products' obtained. These remarks apply to the similar totals quoted in previous *Records*.

A. M. HERON.

M GIPC—M—VIII-4-25—15-5-36—850.

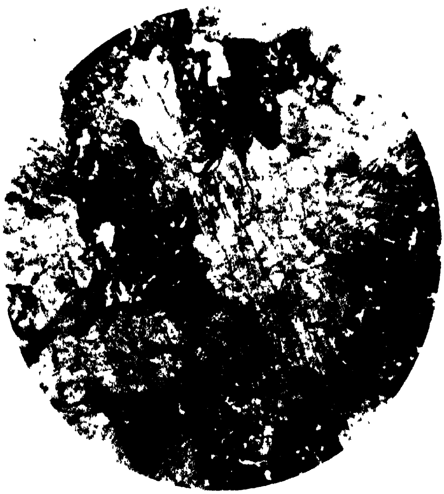

FIG. 1. DOLERITE, FROM NEAR KASIA. (× 24).

FIG. 2. GRANOPHYRE, SOUTH OF HASTINAPUR. (Polarised light, × 24).

P. L. Dutt, Photomicros.

G. S. I., Calcutta.

FIG. 3. GRANOPHYRE WITH EPIDOTE, ONE MILE SOUTH OF GUMARIA. (Polarised light, × 24).

Fig. 4. NORITE, FROM THE DYKE JUST EAST OF DURGAPUR. (× 24).

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 2.] 1936. [July.

THE PERPETI METEORIC SHOWER OF THE 14TH MAY, 1935. BY A. L. COULSON, D.Sc. (MELB.), D.I.C., F.G.S., *Superintendent, Geological Survey of India.* (With Plates 2 to 13 and 1 text-figure.)

CONTENTS.

I.—INTRODUCTION.

Previous notices.

By kind permission of the Director, Geological Survey of India, the first eleven stones of the Perpeti meteoric shower received by this Department were exhibited by the author at the monthly meeting of the Asiatic Society

of Bengal held in Calcutta on the 5th August, 1935.[1] Three additional stones of the same shower, received later, were exhibited at the Asiatic Society of Bengal on the 2nd September, 1935.[2] Copies of the notes describing the exhibits appeared in *Science and Culture.*[3]

Report in 'Ananda Bazar Patrika'.

The shower occurred in the night of the 14th May, 1935, at about 11 P.M. The attention of the Geological Survey of India was first drawn to the fall by Mr. P. C. Roy, Assistant Curator, who made the following translation of the account of it published in the Calcutta edition of the 25th May, 1935, of the vernacular newspaper *Ananda Bazar Patrika* :—

'On the 31st Baisakh last' (14th May, 1935) 'at 11 P.M., an unusual scene was witnessed in a south-westerly direction at different places under the police stations Chandina, Kachua and Hajiganj in the Tippera district, Bengal. Innumerable meteorites fell at Pilgiri, Bhateswar, Perpeti, etc., under police station Chandina. The outer colour of the stones is black while the inner is white. The meteorites are all of different shapes and sizes. Their weight varies from 2 tolas to 15 seers. Fortunately there were no casualties from the fall.'

Letter to the District Magistrate, Tippera.

A letter was then issued by the Geological Survey of India on the 31st May, 1935, to the District Magistrate of Tippera, Comilla (copies being sent at the same time to the police officers of Chandina, Kachua and Hajiganj police stations), enclosing a copy of this translation and requesting him kindly to obtain as complete information as possible regarding the fall and to send the stones to this Department.

Stones recovered from villages under Chandina police station.

Mr. E. W. Holland. I.C.S., the District Magistrate of Tippera, Comilla, obtained and sent to the Geological Survey of India on the 29th June, 1935, eleven specimens, comprising nine separate stones and two pieces of a tenth stone, which were stated to have fallen and been recovered from villages under the jurisdiction of the Chandina

[1] *Advance Proc. and Not. As. Soc. Beng.*, II, No. 5, pp. 65-68, (1935).
[2] *Op. cit.*, No. 6, pp. 77-79, (1935).
[3] *Science and Culture*, No. 4, p. 194, (1935); No. 5, p. 280, (1935). The author was not responsible for the final paragraph in the latter reference concerning a meteoric shower near Comilla. Also *Current Science*, IV, No. 2, p. 120, (1935).

police station. When unpacked, these specimens were registered as Stone, Nos. 298 A-K in the meteorite collections of the Geological Survey of India. Several labels in Bengali were pasted on their surfaces, but most were illegible. Stone 298 D, however, was stated to be 'found by Amir-uddin at 11 A.M. on Wednesday the 16th May on the west of Kula Netra's field'. The only other legible label was on 298 G which was 'found in a box in the possession of Ali Hamid'.

Reports received.

Meanwhile the officer in charge of Hajiganj police station sent in a report on the 6th June; and on the 23rd July, 1935, the District Magistrate forwarded reports from the police officers at Chandina and Kachua, the Sub-divisional Officer of Chandpur and the Hajiganj Circle Officer. From these reports it appeared that there were possibly stones which had fallen in villages under the jurisdiction of the Kachua police station which had not yet been sent to Comilla for despatch to Calcutta. Accordingly a further communication was made to the District Magistrate of Tippera on the 31st July, 1935.

'Statesman' report.

A brief general note on the 'Parpati Phenomenon' appeared in the Calcutta edition of the *Statesman* newspaper of the 3rd July, 1935.

Stones recovered from villages under Kachua police station.

On the 14th August, 1935, a parcel containing three stone meteorites, recovered from villages under the jurisdiction of Kachua police station, was received by the Geological Survey of India from the District Magistrate, Tippera. On the largest stone, 298 L, was a label dated the 18th June, 1935, stating that it fell 'on the eastern side of the house of Rajjob Ali, son of Omar Ali, in a jute field in the village of Chandini. He heard a loud noise and went out and after searching he found this stone. He came today with Chaukidar 8/6 Radha Charan Das to the police station' (Kachua). The middle stone, 298 M, had a label of the same date to the effect that it was found 'in the village Bargi on the western side of Madhu Mia's house in a paddy field. It was brought to the police station' by the same Chaukidar. The smallest stone, 298 N, fell 'in the courtyard of Sailen Das, son of Sambhu Nath Das, in the village of Naula, and was forwarded by Chaukidar 7/4 Dwarika Nath Sial' to the Kachua police station on the 18th June, 1935.

Total weight.

The total weight of all specimens recovered was 23,474·18 grams on their receipt by the Geological Survey of India. The weights of the individual stones are as follows :—

298 A	6,869·85	grams	
B	4,901·05	„	
C	2,671·40	„	
D	2,350·35	„	Specific gravity 3·552.
E	1,905·45	„	
F	1,287·05	„	
G	624·3542	„	„ „ 3·556.
H	595·9844	„	
I	403·7452	„	
J	245·2913	„	
K	88·0475[1]	„	(Slides 23884, 23885, 23886.)
L	1,126·20	„	
M	343·8720	„	
N	61·5323	„	
TOTAL WEIGHT	23,474·18	„	

With the exception of the Merua meteorite[2], with a total weight of 71,406 grams for five pieces, the Kuttippuram meteorite[3] weighing 38,437 grams, and the Patwar meteorite totalling 37,353 grams, which has been described by the author in a separate paper, the total weight of all specimens of the Perpeti meteorite exceeds that of any Indian meteorite in the possession of the Geological Survey of India. The Karkh fall[4] totalled 21,734 grams.

Acknowledgment.

The thanks of the Geological Survey are thus due to the various police and district officers, and especially to E. W. Holland, Esq., I.C.S., the District Magistrate of Tippera, for their successful efforts in obtaining the stones of this Perpeti shower, which form an excellent addition to the collections in the Indian Museum.

II.—CIRCUMSTANCES OF THE FALL.

Details.

'Ananda Bazar Patrika'.

The *Ananda Bazar Patrika* report quoted on page 124 mentioned the phenomena of fall as having been witnessed in a south-west direction.

[1] Now weighs 35·7284 grams (*see* page 134). Additional fragments of this piece 298 K are preserved in a small glass tube.

[2] G. H. Tipper, *Rec. Geol. Surv. Ind.*, LVI, p. 347, (1926).

[3] J. Coggin Brown, *op. cit.*, XLV, p. 211, (1915).

[4] L. L. Fermor, *op. cit.*, XXXV, p. 85, (1907).

Hajiganj police officer.

The officer in charge of the Hajiganj police station reported :—

'I have the honour to report that at the time noted above' (11 P.M. on the 14th May, 1935) 'many people of Hajiganj saw a very brilliant light in the sky passing from south-west to north-east. No meteorite fell in this jurisdiction. I hear that hard, stone-like substances fell in the ground at and near about Pilgiri village. Three high sounds like those of bombs were also heard at that time'.

Mr. J. N. Chakraborty.

Mr. J. N. Chakraborty, Sub-Inspector of police in charge of Kachua police station, wrote on the 21st June, 1935, that :—

'———— on enquiry it was learnt that 3 (three) meteorites of different weight fell on the places noted below in this P. S. *Elaka*[1] which have all been taken charge of by me on 18th June, 1935, and kept in this P. S. *malkhana*[2] awaiting orders for their disposal.

(1) One meteorite fell on the night of 31st May, 1935[3] at village Changini to the east of Rajabali's house in the field. It weighs 1¼ seers.[4]

(2) The 2nd one, which weighs 6 chataks[5], fell at village Barapara to the west of Madhu Babu's house in the field on the same night.

(3) The 3rd one, weighing one chatak[6], fell in the yard of one Kailash Ch. Das of Naula on the very night.'

These three specimens are undoubtedly 298 L, M and N mentioned on page 125 as being labelled to the effect that they were picked up in the villages Changini, Bargi and Naula, respectively.

Mr. Chakraborty added that

'there was thunder first, then the sky appeared to be lighted. Then there was 3 or 4 roaring sounds which were followed by the fall of the meteorite. A light appeared to have run from west to east in the sky. As for the direction of the fall, nothing could be said.'

The recovered pieces were cold when collected and there was no characteristic smell in the neighbourhood. Only one piece fell at each locality.

It will be remembered, however, that according to the label on the stone (298 L) that fell at Changini, Rajjob Ali recovered this on the night of the shower; but no mention was made of whether or not the stone was cold when he picked it up.

[1] Subdivisional area.
[2] Store.
[3] Really the 14th May, 1935, or the 31st Baisakh.
[4] 2½ pounds.
[5] 12 ounces.
[6] 2 ounces.

Babu Harendra Mohan Naha, Sub-Inspector of police in charge of Chandina police station, stated that about 11 P.M. on the 14th May, 1935, ten meteorites fell in different villages in the fields and houses of persons of 'Union No. XIV (Adda)' under Chandina police station. Light phenomena accompanied the fall which appeared to take place in the south-west 'corner'. The meteorites were recovered the following morning and were then cold. There was no characteristic smell and only one stone fell in each locality. These ten meteorites were those numbered 298 A-K.

Babu Harendra Mohan Naha.

Mr. S. Ahmed, Circle Officer of Hajiganj, stated that the meteorites fell in many places under the jurisdiction of Chandina police station and in the villages Krishnapur and Changini under Kachua police station. A strong light 'like a search light' accompanied the fall which was in the north-east part of the police subdivision. When recovered the following morning, the meteorites were cold and 'there was no smell received by the neighbouring houses'.

Mr. S. Ahmed.

Conclusions.

No information regarding depth.

For all stones, there is no information available as to the depth to which they penetrated on reaching the earth.

Scarcity of precise information regarding the distribution of the stones.

Though the recovery of stones from this meteoric shower of the 14th May, 1935, has been surprisingly good, the total weight being almost 23,500 grams, yet disappointment must be felt at the lack of precise information as to the distribution of the individual stones. In this sense, the Perpeti meteoric shower compares unfavourably with the Dokachi meteoric shower of the 22nd October, 1903, described by Sir Lewis Fermor[1], though the weight recovered then was much less than in the present shower.

Text-fig. 1 shows the distribution of the villages from which stones are reported to have been collected; but it may be noted here that 298 M is said to have come both from Bargi and also from Barapara. These two villages, together with Naula and Changini, are under the jurisdiction of Kachua police station. The other

[1] *Rec. Geol. Surv. Ind.*, XXXV, pp. 68-78, (1907)

villages—Perpeti (23° 19′ : 91° 0′)[1], which gives its name to the shower, Pilgiri[2], Bhateswar and Krishnapur—are under the jurisdiction of Chandina police station.

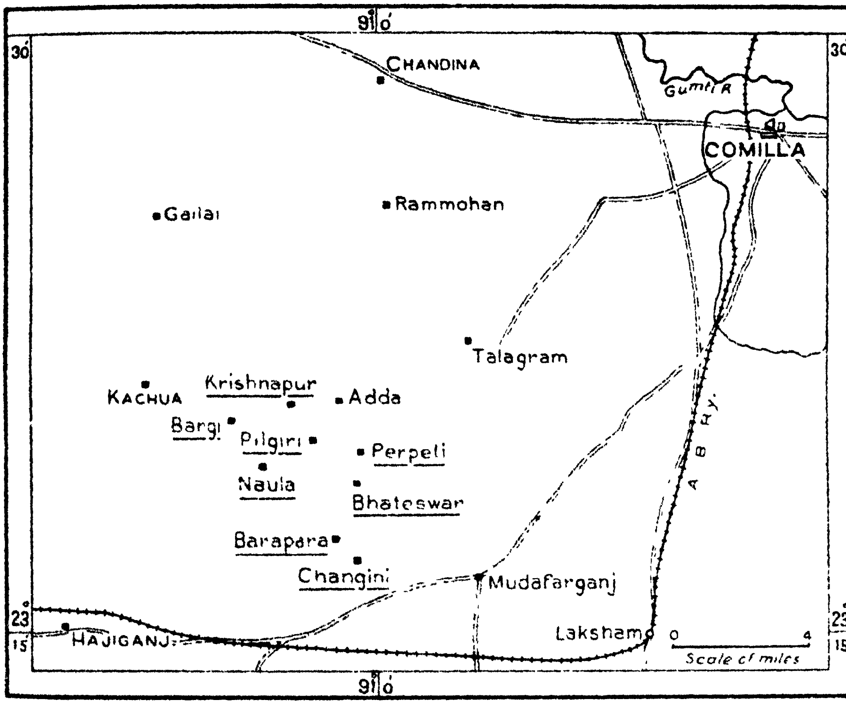

FIG. 1.—Sketch map showing villages (underlined) from which stones of the Perpeti meteoric shower were recovered.

Greatest weight recovered from north-eastern villages.

The total weight recovered from the Kachua police subdivision is 1,531·604 grams, the largest piece, 298 L, weighing 1,126·20 grams, being recovered from Changini. In the Chandina police subdivision to the north-east, 21,942·57 grams were recovered, the largest piece, 298 A, weighing 6,869·85 grams and no fewer than six specimens exceeding the weight of the large piece at Changini.

[1] The large village Perpeti occurs mainly just inside the one-inch sheet 79 M/3, (1933 edition), but it extends on to the adjoining one-inch sheet 79 I/15 (1923 edition). On this latter sheet, about half a mile to the south-west, a small village named Herpeti is shown; this village Herpeti is shown on the quarter-inch map 79 I (1926 edition), but there is no modern edition of the adjoining sheet 79 M.

[2] Not to be confused with Palgiri, some 2½ miles to the W. S. W.

All reports agree in stating that the light appeared in the south-west and so it appears almost certain that the apparent direction of movement of the original primitive meteorite was from south-west to north-east; the resultant shower of stones on the disruption of the parent meteorite, on encountering the earth's atmosphere, continued in this general direction. All the villages named above are included in a rectangular area five miles long by three miles wide, the supposed direction of flight (south-west to north-east) being in the direction of the shorter side.

Direction of movement of primitive meteorite and of resultant stones from south-west to north-east.

In the case of the Dokachi shower, Sir Lewis Fermor was able to show conclusively that the larger stones travelled further in the original direction of motion of the primitive meteor, their greater mass, and consequent greater momentum, rendering them better able to overcome the resistance of the atmosphere. With the Perpeti shower this seems generally true, as the greater mass of stones fell in the Chandina police subdivision to the north-east. In the Dokachi shower, however, a rectangular area embracing localities from which stones were recovered had its elongation in the direction of flight, the reverse case to that found in the Perpeti shower.

Comparison with Dokachi shower.

As will be seen in the general description of the stones, with only one exception in the case of 298 L, all specimens are alike in not showing secondary crusts due to the further disruption of the stones produced by the break-up of the parent meteor. They show a uniform, thin, dark crust with very similar characteristics in all cases. Most of the specimens appear to be more or less completely crust-covered and do not seem to have lost very much material by human agency, except in the case of 298 A. 298 B, D, E, G, I and N are particularly good examples of crust-covered stones. It would appear, therefore, that all the stones had a nearly uniform period of flight through the atmosphere.

Only one example of secondary crust.

The stone 298 L is interesting in being the sole stone on which secondary crusts have been developed. These seem of equal thickness and would seem to indicate that this stone was disrupted once after it was born of the parent meteorite.

Flow lines.

A system of immature flow lines is weakly developed on the side of 298 N forming Plate 12, figure 7.

III.—GENERAL DESCRIPTION OF THE STONES.

298 A.

The largest stone, 298 A, weighing 6,869·86 grams, is far from complete, one side being a fracture surface, approximately six inches by five inches, made by human agency after its fall to the earth. This fracture surface must have been moistened, for the nickel-iron and troilite have since rusted and the formerly light-coloured surface has been darkened. Possibly a piece weighing some two to three kilograms was broken off from 298 A and retained locally.

The stone is now roughly tetrahedral or arrow-headed in shape, the longest sides being about nine inches in length. It is possible, also, that the whole stone was originally arrow-headed in shape and that the fragment broken off is of no great size. If so, the stone's pointed end, opposite from the fracture surface, was directed in its line of motion through the atmosphere.

Plate 2, figures 1 and 2, and Plate 3, figure 1, show the crustal areas of the stone. No definite flow lines can be observed, but that side seen in Plate 2, figure 1, shows numerous elongated depressions, some of which are compound in form and as much as two inches in length. The crust is generally thin (less than 0·5 mm.) and grey-black in colour, but occasionally shows jet-black, somewhat glazed, oval-shaped marks which appear to represent the location of exceptionally fusible constituents in the surface of the stone. Small excrescences indicate the presence of the relatively refractory nickel-iron (*see* Plate 2, figure 1). The general characters of the crust of this and the other stones are compatible with the view that since the disruption of the parent meteorite there has been but sudden, brief heating.

298 B.

Stone 298 B, which weighed 4,901·05 grams when received, has somewhat the appearance of a truncated spheroid, one side of which is slightly flattened. Its height is about five inches. One can imagine its rounded surface, which is well seen in Plate 4, figure 1, being pointed towards its direction of motion, the heat generated by its passage through the atmosphere being sufficient to abrade the corners of the original

fragment to a more rounded form.[1] The flattened base of the stone, which is roughly about five inches square (Plate 3, figure 2), shows numerous minor shallow depressions, a few of which, however, are of considerable depth.

It is thought that the shape of the spheroidal part of this stone 298 B has not been greatly altered by the removal of the crust, which was effected either by accident or design by human or mechanical agencies. The scratchings and excavations of the more inquisitive of those who found the specimen are plainly seen in the hand specimen and may be noted in the upper part of Plate 4, figure 1.

This stone has a very thin crust with the same characters as described for 298 A. The crustless areas have not rusted as much as those of that stone.

298 C.

Stone 298 C weighed 2,671·40 grams when received. Its shape calls for no particular comment; its greatest diagonal is about six inches. It is not completely covered with crust, as about some 400 grams, possibly, have been broken off by human agency from the two large crustless areas shown well in Plate 5, figure 2. Plate 5, figure 1, shows a peculiar, tongue-shaped area of dull-glazed, black crust which is probably the result of fusion of a relatively large mass of more easily fusible material such as troilite. Plate 5, figure 3, shows the very irregular nature of certain faces of 298 C, the surface being pitted with many depressions.

298 D.

Stone 298 D, which weighed 2,350·35 grams on receipt, is an almost complete specimen with just a few grams weight chipped off the corner shown in Plate 6, figure 4. Its crust is slightly darker in colour than in the majority of the other stones, but it otherwise possesses their general characteristics. Besides the above figure, it is depicted in Plate 6, figures 1-3. It is somewhat trigonal in its upper part and its greatest length is about 5½ inches.

The specific gravity of this stone was found to be 3·552.

Stone 298 E is also an almost complete specimen, only a few grams weight of crust having been removed before it was received

[1] Should its original form have been conical, the subsequent action of the atmosphere would tend simply to preserve this form. *See* Schlichter, *Geol. Soc. Amer.*, Bull. 14, pp. 112-116, (1903).

298 E. by the Geological Survey of India; its weight on arrival was 1905·45 grams. Its longest diagonal is about six inches. Four views of its crust are shown in Plate 7. They call for no special comment.

Stone 298 F, which weighed 1287·05 grams on receipt, has probably suffered the loss by human or other agency of some 200 grams weight. It is a fairly complete specimen; its longest diagonal is about 5½ inches. Its shape, as seen in Plate 8, calls for no comment except that some of its faces show numerous irregular minor depressions (*see* figures 1 and 3).

298 F.

Stone 298 G, which weighed 624·3542 grams on receipt, is an almost complete specimen, somewhat similar in shape to the smaller stone 298 I. Its width (2¾ inches) is almost double its thickness (1½ inches), while its greatest length is about 4½ inches. It is depicted in Plate 9, its largest faces forming figures 3 and 4.

298 G.

The specific gravity of 298 G is 3·556.

Stone 298 H is rather weathered on its crustless areas, the extent and nature of which seem to indicate that a fair amount of the stone has been broken off. Its weight when received was 595·9844 grams. Two views of this stone are given in Plate 10, figures 1 and 2. It is of no particular shape, its longest diagonal being about three inches.

298 H.

The somewhat rectangular stone 298 I weighed 403·7452 grams when received; it is a particularly fine specimen save for the absence of some very minor chipped areas of crust. It is roughly 3 × 2 × 1½ inches in dimensions and is shown in Plate 10, figures 2-5.

298 I.

Stone 298 K was originally part of 298 J, from which it must have been broken off by human agency. The latter stone weighed 245·2913 grams and the former, 298 K, 88·0475 grams on receipt. Stone 298 K had three sections made from it and also part of it was used for a bulk chemical analysis by Mr. P. C. Roy without separation into attracted and unattracted portions. Its weight when photographed was 76·3815 grams. Later more fresh, crustless material was broken from 298 K for analyses of the attracted and unattracted portions by Mr. Roy and by Dr. E. Spencer and Mr. K. B. Sen and the stone

298 J and K.

now weighs 35·7284 grams. Fragments of this piece are also preserved in a small glass tube.

The parent stone of these fragments 298 J and K was rectangular in shape and about 3 × 2¼ × 1½ inches in dimensions. Certain of its faces show numerous shallow depressions which are seen in the various views forming Plate 11. The stones have a white, rather friable mass. Nickel-iron and troilite show up well on the fractured surfaces.

298 L.

Stone 298 L, recovered from Changini village, is perhaps the most interesting specimen of the shower. It weighed 1,126·20 grams when received and its longest diagonal is about 4½ inches. Three of its faces are covered with the usual, relatively smooth, thin crust characteristic of the other stones of this shower. One face is a fracture surface on which the nickel-iron has rusted considerably; it is probably due to human agency and it is not possible to estimate accurately the amount so broken off. The other two faces are coated with what appears to be a secondary crust, due to the exposure to the atmosphere of fresh fracture surfaces developed when a later disruption in the atmosphere broke off pieces of the stone. Very imperfect fusion appears to have taken place on these surfaces and the resultant coarse, black, rough crust is depicted in Plate 12, figure 2. It shows up well in contrast with the usual crust and is about 2½ inches by two inches on both faces.

298 M.

Stone 298 M weighed 343·8720 grams when received. It is not a complete specimen but probably only about 100 grams have been broken off. Unfortunately those responsible for the despatch of the stone have been rather liberal with the gum that stuck the explanatory label to its surface. Neither its shape nor its crust call for particular comment. Its greatest diagonal is about 3¼ inches. It is depicted in Plate 12, figures 3-5.

298 N.

Stone 298 N, which weighed 61·5323 grams on receipt, is the almost complete crust-covered little specimen seen in Plate 12, figures 6 and 7. It is about two inches in length by one inch square in lateral dimensions. It is interesting in being the sole stone on which flow lines can be discerned, there being a poorly developed system of such lines on the side of the stone shown in Plate 12, figure 7.

IV.—MICROSCOPICAL EXAMINATION.

Few chondri.

Thin sections of the stone 298 K, Nos. 23884-23886 in the collections of the Geological Survey of India, show that the meteorite has few, chiefly white, chondri. It is not veined.

Nickel-iron.

There is in the sections a fair amount of nickel-iron, which is steel-grey by reflected light and occurs in shapeless masses, sometimes with a tendency to spheroidal form. According to the analysis, the meteorite contains 8·24 per nickel-iron with Fe : Ni = 6 : 1 approximately.

Troilite.

Troilite (pyrrhotite) is present to about an equal extent to nickel-iron (6·10 per cent.). It likewise occurs in shapeless masses and grains and appears various shades of bronze by reflected light. It is frequently intergrown with the nickel-iron.

Magnetite.

Both the nickel-iron and the troilite are opaque by transmitted light. By reflected light, however, as noted above, their appearance is very dissimilar. There is another mineral present in fair amount which is also black by transmitted light; by reflected light, however, it is also black and shows up well in contrast with the nickel-iron and troilite. Sometimes this black mineral is dull; but generally it has a somewhat metallic appearance and is almost certainly magnetite, very finely crystalline. This is also borne out by the relatively large percentage of Fe_2O_3 (4·21) in the bulk analysis, which gives rise to 6·12 per cent. of magnetite in the calculated composition.

It will also be remembered that Farrington[1] has shown that the crust formed on the surface of iron meteorites in passing through the air has the composition of magnetite. Magnetite has also been formed in the crust of this Perpeti stone meteorite by the oxidation of nickel-iron and troilite.

Chromite.

A few flakes of a reddish, transparent, isotropic mineral are probably chromite. Also some of the opaque, black mineral is probably chromite. The chemical analysis shows 0·65 per cent. Cr_2O_3.

The commonest silicate mineral is perhaps olivine, which occurs frequently as hypidiomorphic crystals, sometimes simply twinned,

[1] *Pub. Field Mus.*, Geol. Ser., III, p. 176, (1910).

Olivine. grains, granular aggregates, and as lamellæ in chondri intergrown with glass and with clinoenstatite. Sometimes the olivine crystals are surrounded by enstatite.

Clinoenstatite. Clinoenstatite appears as grains and as crystals as well as in lamellæ in chondri intergrown with olivine and less commonly with enstatite. It is marked chiefly by its oblique extinction. In slide 23885, large crystals of clinoenstatite are arranged around a large central olivine crystal.

Enstatite. Enstatite is present in the form of small and large crystals and as lamellæ in chondri. Some of it at least appears to be negative in optical character.[1]

? Apatite. A colourless mineral with high refractive index, very low polarisation colours (greys), an occasional cleavage with straight extinction but more commonly uncleaved, occurs in the sections. It has a triangular outline in one example (23886; Plate 13, figure 3), but usually (23884, 23885, 23886) it is most irregular in outline. Sometimes it is practically isotropic. The optical character of the mineral is indefinite; it is possibly biaxial. Its appearance, however, in certain sections is strongly reminiscent of apatite, which though a rare constituent, has been recorded from the Kodaikanal and Angra dos Reis meteorites. The percentage of P_2O_5 (0·27) present in the chemical analysis (*see* page 139) is compatible with the view that the mineral in question is apatite. The phosphorus was found only in the unattracted material and so has not been attributed to schreibersite. It is interesting, however, to note that Farrington[2] mentions the occurrence of a colourless mineral of irregular outlines, which is weakly birefringent, biaxial, and probably positive, that has been ascribed by Merrill[3] to francolite (which is negative). According to E. S. Larsen[4], this mineral has the composition :—

$$10\ CaO.\ 3\ P_2O_5.\ CO_2.\ CaF_2.H_2O.$$

Felspar. A little oligoclase felspar (23886), its twinning lamellæ having almost straight extinction, was noted. The percentage of alumina (1·35) in the bulk analysis is very small.

Glass. Glass is not a common constituent of this Perpeti meteorite, but can be seen intergrown

[1] J. P. Iddings, 'Rock Minerals', New York, p. 303, (1911).
[2] 'Meteorites', Chicago, p. 188, (1915).
[3] G. P. Merrill, *Mem. Nat. Acad. Sci. Wash.*, XIV, No. 1, p. 23, (1916).
[4] *U. S. Geol. Surv.*, Bull. 848, p. 170, (1934).

with lamellæ of olivine in chondri, and in small, separate, isolated masses.

Oldhamite.

Oldhamite, the soluble sulphide of lime, was not recognised under the microscope; even if originally present, it would have been removed from the thin section in its preparation. Its presence in the Perpeti meteorite was proved by chemical tests.[1]

V. CHEMICAL ANALYSIS.

Analyses by Mr. P. C. Roy.

Preliminary analyses on attracted and unattracted portions of a sample of the Perpeti meteorite were kindly made by Mr. P. C. Roy, Assistant Curator; but as the insolubles of the attracted were not added in the correct proportion to the unattracted, the results are not given. They were very useful, however, in serving as a guide to the later analyses, given below, by Messrs. Spencer and Sen. Mr. Roy also almost completed a bulk analysis without separation into attracted and unattracted parts.

Analyses by Dr. E. Spencer and Mr. K. B. Sen.

I am greatly indebted to Dr. E. Spencer and Mr. K. B. Sen for an analysis of part of 298 K, a specimen of the Perpeti meteorite, carried out in Messrs. Bird and Co.'s Research Laboratories in Calcutta under their supervision. Dr. Spencer has kindly submitted the following note upon the results obtained :-

'The method of analysis followed in the first estimation was the same as that described by G. T. Prior.[2] By this method the magnetic portion is first separated from the powdered material and the whole of the magnetic portion is treated with hydrochloric acid of 1·06 specific gravity with a few ccms. of nitric acid. This removes the iron-nickel alloy, together with the olivine and other minerals soluble in the acid mixture. The soluble portion is examined separately and the insoluble residue is added to the original non-magnetic portion which is then taken as a combined sample for analysis by the usual methods of rock analysis.

Sulphur was determined on a fresh sample of the meteorite using the method described by Ennos[3], an absorption flask being used to trap the traces of sulphuretted hydrogen which escape from this sample on treatment with acid even in the presence of bromine.

A check estimation of the amount of free nickel-iron and troilite was also carried out by the method described by M. H. Hey[4], using dry chlorine and volatilising the iron, sulphur and a portion of the phosphorus. The residue from this estimation was again used to check the remaining constituents.

[1] G. P. Merrill, *loc. cit.*, p. 25.
[2] *Min. Mag.*, XVII, pp. 24-25, (1913); pp. 132-133, (1914).
[3] *Op. cit.*, XIX, pp. 326-327, (1922).
[4] *Op. cit.*, XXIII, pp. 48-50, (1934).

Although in the first estimation by Prior's method, the basic acetate method of separating the iron was employed, it was found in the check tests that the ordinary routine steel-works methods of estimating the various constituents (in which the iron is either kept in solution with tartaric acid or with acetic acid) gave satisfactory results. We see no reason why the very tedious basic acetate separation[1] should be insisted upon, except where the quantity of material available for analysis is very small.

The steel-works methods are not only much more rapid, but in our opinion more reliable, the basic acetate method, unless very carefully carried out, being liable to very serious errors.'

The weights taken in the attracted and unattracted portions were as follows :—

Attracted	1·2055 grams.
Unattracted.	7·4775 grams.

Analysis of the attracted portion.	Per cent.	Analysis of the unattracted portion *plus* the insolubles from the attracted portion.	Per cent.
Fe	50·74	SiO_2	42·77
Ni	8·57	TiO_2	0·18
Co	0·39	Al_2O_3	1·53
SiO_2	8·25	Fe_2O_3	4·74
FeO	4·18	Cr_2O_3	0·73
CaO	0·70	FeO	11·97
MgO	6·47	MnO	0·30
FeS { Fe	0·87	CaO	2·00
FeS { S	1·52	MgO	27·30
Insolubles	18·79	Na_2O	1·32
TOTAL	100·48	K_2O	0·16
		P_2O_5	0·30
		FeS { Fe	4·13
		FeS { S	2·36
		CaS { Ca	0·09
		CaS { S	0·07
		TOTAL	99·95

[1] *See* also M. H. Hey, *op. cit.*, XXIII, pp. 12-13, (1934).

Bulk analysis. The following is the bulk analysis calculated from the foregoing analyses of the attracted and unattracted portions:—

		Bulk analysis.	Atomic and molecular ratios.
		Per cent.	
Fe		7·01	0·1252
Ni		1·18	0·0200
Co		0·05	0·0008
FeS	Fe	3·88	0·0693
	S	2·22	0·0694
SiO_2		39·09	0·6515
TiO_2		0·16	0·0020
Al_2O_3		1·35	0·0132
Fe_2O_3		4·21	0·0263
Cr_2O_3		0·65	0·0043
FeO		11·19	0·1554
MnO		0·27	0·0038
CaO		1·88	0·0336
MgO		25·11	0·6278
Na_2O		1·17	0·0189
K_2O		0·14	0·0015
P_2O_5		0·27	0·0019
CaS	Ca	0·08	0·0020
	S	0·06	0·0019
TOTAL		99·97	

Composition of the olivine. An analysis of the portion of the unattracted *plus* insolubles soluble in hydrochloric acid gave the following results:—

		Molecular ratios.
	Per cent.	
SiO_2	20·95	0·3492
FeO	11·97	0·1662
MgO	18·30	0·4575
CaO	0·35	0·0062
Fe,S, etc.	6·65	
Insolubles	42·00	
TOTAL	100·22	

From the percentages of FeO, MgO and SiO_2 in the above analysis, the composition of the olivine approximates to 3 Mg_2SiO_4. Fe_2SiO_4.

Mineral composition calculated from the bulk analysis.

The mineral composition of the Perpeti meteorite as calculated from the bulk analysis given on page 139 and from the known composition of the olivine ($3Mg_2SiO_4 . Fe_2 SiO_4$) is as follows:—

Ratios.	Percentages.		
1252 Fe	7·01	8·24	Nickel-iron.
200 Ni	1·18		
8 Co	0·05		
693 Fe	3·88	6·10	Troilite.
694 S	2·22		
20 Ca	0·08	0·14	Oldkamite.
19 S	0·06		
43 $FeO.Cr_2O_3$		0·96	Chromite.
263 $FeO.Fe_2O_3$		6·12	Magnetite.
20 $FeO.TiO_2$		0·30	Ilmenite.[1]
19 $3 Ca_3P_2O_8.CaO$		1·33	Apatite.
117 $Na_2O.Al_2O_3.6 SiO_2$	6·13	6·96	Felspar.
15 $K_2O.Al_2O_3.6 SiO_2$	0·83		
511 $Fe_2 SiO_4$	10·42	31·90	Olivine.
1534 $Mg_2 SiO_4$	21·48		
206 $Fe SiO_3$	2·72	37·01	Enstatite and clinoenstatite.
3210 $Mg SiO_3$	32·10		
146 $Ca SiO_3$	1·69		
38 $Mn SiO_3$	0·50		
72 $Na_2 SiO_3$		0·88	? Pyroxene.
	TOTAL	99·94	

[1] The titania has been ascribed to ilmenite though it may be in the clinoenstatite.

VI.—CLASSIFICATION OF THE FALL.

Classification according to Brezina.

The Perpeti fall has been classified as a white chondrite, Cw, in Brezina's classification[1]—'white, rather friable mass with scarce, mostly white chondrules'.

Classification according to Prior.

In Prior's classification of meteorites[2], the Perpeti fall belongs to the Baroti and Soko-Banja types, hypersthene-olivine-chondrites, wherein the ratio Fe : Ni varies from about 7 to 3 : 1 and the percentage of nickel-iron is generally less than 10. In the Perpeti fall, the ratio Fe : Ni = 6 : 1 and the total percentage of nickel-iron = 8·24 per cent. The ratio Mg O : Fe O in the olivine = 3 : 1.

VII.—DISPOSAL OF THE SPECIMENS.

Exchanges.

Stone 298 F, weighing 1,287·05 grams, will be presented in exchange to the British Museum, Natural History, South Kensington. Stone 298 M, weighing 343·8720 grams, will be presented in exchange to the National Museum of Natural History, Paris. Plaster casts of both stones will be retained by the Geological Survey of India. The remaining stones of this important shower will be retained in the collections of the Geological Survey of India in the Indian Museum, Calcutta.

VIII.—EXPLANATION OF PLATES.

PLATE 2, FIG. 1.—Side of 298 A, showing the arrow-headed form of the stone.

FIG. 2.—Adjacent side of 298 A, showing numerous shallow depressions, sometimes compound in nature.

PLATE 3, FIG. 1.—Side of 298 A, opposite to that shown in Plate 1, figure 2.

FIG. 2.—Truncated base of 298 B, with numerous small depressions. The crustless areas shown in this and succeeding views of this stone were probably covered with crust which has since been removed either by accident or design.

PLATE 4, FIG. 1.—Top and lateral view of the spheroidal part of 298 B, showing a compound system of relatively deep depressions. Scratches of human agency may be seen on the upper crustless area.

FIG. 2.—Flattened side of the spheroidal part of 298 B.

[1] *Proc. Amer. Phil. Soc.*, XLIII, p. 234, (1904).

[2] *Min. Mag.*, XIX, pp. 51-63, (1920). See also *op. cit.*, XVIII, pp. 26-44, (1916) pp. 349-353, (1919).

PLATE 5, FIG. 1.—Side of 298 C, showing a small glazed area of crust due to the fusion of a relatively large mass of more easily fusible material, probably troilite.

FIG. 2.—Side of 298 C, showing two large crustless areas from which pieces have been broken off.

FIG. 3.—Side of 298 C, showing numerous crustal depressions.

FIG. 4.—Side of 298 C.

PLATE 6, FIG. 1.—Base of 298 D, an almost complete stone.

FIG. 2.—Base and side of 298 D, showing crustal depressions.

FIG. 3.—Side of 298 D.

FIG. 4.—Side of 298 D, with numerous depressions and showing pointed top of the stone.

PLATE 7, FIG. 1.—Side of 298 E, an almost complete stone.

FIG. 2.—Side of 298 E.

FIG. 3.—Side of 298 E.

FIG. 4.—Side of 298 E.

PLATE 8, FIG. 1.—Side of 298 F, showing numerous depressions.

FIG. 2.—Opposite side to above.

FIG. 3.—Very irregular surface of 298 F.

FIG. 4.—Smooth side of 298 F.

PLATE 9, FIG. 1.—Side of 298 G, an almost complete stone.

FIG. 2.—Opposite side of 298 G.

FIG. 3.—Largest face of 298 G.

FIG. 4.—Opposite face of 298 G.

PLATE 10, FIG. 1.—Side of 298 H, a very incomplete stone weathered on its crustless areas.

FIG. 2.—Side of 298 H.

FIG. 3.—Side of 298 I, an almost complete stone.

FIG. 4.—Side of 298 I.

FIG. 5.—Side of 298 I.

PLATE 11, FIG. 1.—Side of 298 J, an incomplete stone, showing numerous shallow depressions. The side of 298 K shown in Fig. 5 originally joined this side.

FIG. 2.—Opposite side of 298 J. The side of 298 K shown in Fig. 6 originally joined this side.

FIG. 3.—End of 298 J, showing depressions.

FIG. 4.—Base of 298 J, showing numerous depressions.

FIG. 5.—Side of 298 K, a fragment broken off from the large stone 298 J. This and the next view were taken when K weighed 76·3815 grams and not 56·3074 as at present.

FIG. 6.—Opposite side of 298 K.

PLATE 12, FIG. 1.—View of 298 L, an incomplete stone.

FIG. 2.—Opposite view of 298 L, showing a rough secondary crust, S, on two faces, the usual smooth crust, C, showing up well in contrast. F is a fracture surface.

FIG. 3.—View of 298 M, an incomplete stone.

FIG. 4.—View of 298 M.

FIG. 5.—Side of 298 M, adjacent to Fig. 3 above, showing numerous depressions.

FIG. 6.—Side of 298 N, an almost complete stone.

FIG. 7.—Opposite side of 298 N, showing shallow depressions, badly developed flow lines, and some minor crustless areas.

PLATE 13, FIG. 1.—Photomicrograph of 298 K, thin section 23884, showing an eccentric chondrus composed of lamellæ of olivine, clinoenstatite and enstatite, and grains and larger crystals of nickel-iron and troilite (both black), olivine, enstatite (rare in this photo) and colourless ? apatite. × 16.

FIG. 2.—Photomicrograph of 298 K, thin section 23885, showing the general structure of the stone. A granular olivine aggregate, larger olivine crystals, enstatite (lighter colour) and troilite, magnetite and nickel-iron (last three black) may be seen. × 36.

FIG. 3.—Photomicrograph of 298 K, thin section 23886, showing a triangular section of colourless apatite surrounded by grains, lamellæ and crystals of olivine, with other crystals of olivine, clinoenstatite enstatite, and nickel-iron and troilite (last two black). × 36.

THE TIRUPATI AND BAHJOI METEORITES. BY M. S. KRISHNAN, M.A., PH.D., A.R.C.S., *Assistant Superintendent, Geological Survey of India.* (With Plates 14 to 18.)

CONTENTS.

I. INTRODUCTION.

Mention has already been made[1], in the General Report of the Geological Survey of India for the year 1934, of four falls of meteorites in India during that year. Material representing only two of the falls has been picked up. A description of these will be given in this note.

II. TIRUPATI STONE METEORITE.

This fell at about 6-30 P.M. on the 20th March, 1934, in the Sakamvaripalle hamlet of Nennoor[2], which is described by the local authorities as situated about six miles to the south-east of Tirupati (13° 38′ : 79° 25′), a famous place of pilgrimage in the Chittoor district of the Madras Presidency.

The meagre report of an eye-witness, recorded by the local police official, states :

> 'The meteorite came from the north-east towards the south-west with a thundering noise and fell close to his house with a flash of lightning, creating a depression on the ground as it fell. The stone was rectangular in shape, about 6 in. × 4 in. × 2 in. Two persons witnessed this incident.'

Another piece was picked up from a garden amidst the fields of Sakamvaripalle. Some boys who saw the fall were not able to give any particulars.

[1] *Rec. Geol. Surv. Ind.*, LXIX, pp. 15-16, (1935).

[2] Nennoor is not to be found in the map, sheet 57 O/6, in the location indicated by the local authorities. There is a Nennuru six miles due south of Tirupati. The direction from Tirupati was erroneously given as north-east in the General Report for 1934.

Three pieces from this fall were received by the Geological Survey of India through the Director-General of Observatories at Poona, and two more and some small fragments were later received direct from Puttur. Two fragments, of a total weight of just over one gram, were used up for making thin sections. The weights and specific gravity of the remaining material are as given below :—

Piece.	Weight.	Sp. gr. (25°C.).
I	81·7870 grams.	3·603
II	45·2540 „	....
III	28·9046 „	3·617
IV	16·2207 „	....
V	35·9096 „	....
Fragments	22·2970 „	....
TOTAL WEIGHT .	230·3729 grams	

The pieces (Plate 14) are all small in size, none being more than two inches across, and irregular in shape. A thin black fused crust is seen over only parts of the pieces, as the original lumps had been broken up before they reached the local authorities. There are also slight depressions on the surface but no definite flow lines from which the direction of flight could be inferred. The broken surfaces of Nos. II and IV are light grey in colour and fresh-looking, while those of the others are stained brown in places because of slight weathering. They are fairly compact in texture but with a slight tendency to friability. Spherulitic chondri as well as minute specks of nickel-iron and of metallic yellow troilite can be seen.

Under the microscope (thin section 23887) a few rounded chondri are seen but the major part has a granular texture. The most prominent mineral is olivine, which occurs as comparatively large individuals. Enstatite is also fairly abundant, while the mineral giving oblique extinction may probably be clinoenstatite. In places a distinct porphyritic structure is seen. In one slide a rounded grain of olivine shows a rim of a different mineral, which may be enstatite. The granular ground mass contains the above-mentioned minerals as well as a large number of grains of troilite and nickel-iron. A few grains, distinctly darker and comparatively sub-

metallic in reflected light, may be magnetite. Besides, there are some individuals showing weak birefringence but they are too small to be identified with certainty, especially as the sections happen to be somewhat thick.

The Tirupati meteorite can be classed as a white chondrite[1] (Cw) in Brezina's scheme. It has been registered under No. 297 among the stone meteorites in the collections of the Geological Survey of India.

III. BAHJOI IRON METEORITE.

The *Statesman* of Calcutta of the 2nd of August, 1934, contained the following news item sent by a correspondent of the *Associated Press* from Moradabad :—

' What is believed to be a piece of meteor which was seen at Delhi and in several neighbouring districts in the United Provinces on the night of July 23rd, has been brought to headquarters (Moradabad) by the station office of the Bahjoi Police Station in the Moradabad district.

It is like a piece of iron, dark in colour, irregular in shape, somewhat resembling a triangle and being throughout covered with holes more than an inch in diameter. It is about a foot long and an inch thick but much heavier than iron. It weighs 11 *seers* and 12 *chhataks*.[2] It glistens in two or three places like silver and is impervious to heat.

It appears that two days after the fall of the meteor, some cowherds, while grazing cattle in the village of Chandankuti, saw something protruding from the ground which they dug out and sent to the Police. '

The Delhi edition of the same newspaper of the 24th July, 1934, reported :—

' Delhi residents had the thrill, at 9-35 last night, of seeing the ground lit up for about 20 seconds by what seemed to be a meteor. They state that it disappeared into the east, emitting a bright bluish light. It is reported to have fallen at Hapur, about 40 miles from the city, where people hired *tongas* (pony carts) and searched the district for the supposed meteor.'

The science monthly, *Current Science* of Bangalore, contained the following note on page 84 of its August, 1934, issue :—

' *An unusual meteor.*—Mr. Zakiuddin of Aligarh University writes : On Monday the 23rd July, 1934, at 9-30 P.M. an unusual meteor appeared above the clouds that

[1] My colleague, Dr. A. L. Coulson, who examined the thin sections, found much similarity between this and the Perpeti meteorite which he has described (see *ibid*, pp. 123-143).

[2] Equivalent to about 10·963 kg.

hovered over the horizon of Aligarh. The meteor started from the south-west and travelled south-east at about 50° (above the horizon) with unusual brilliance, lighting the ground for about 15 seconds. At the beginning it appeared like a ball of fire that afterwards developed a source of extraordinary light. Later on it began to emit bright bluish light and split into two portions at about 20° from the horizon. It is said to have fallen near Hapur, about 40 miles from Delhi.'

Enquiries by the authorities of Delhi, Meerut, Hapur and other neighbouring places revealed that no meteorites were found in those places. Though there was no eye-witness to the actual fall at Chandankati Muazam (28° 29′ : 78° 30′ 30″), which is situated at about nine miles south-west of Moradabad and 1½ miles north-west of Bahjoi, there is little doubt that the piece recovered from there belonged to the phenomenon described above.

Mr. R. B. Connell, a retired officer of the Indian Service of Engineers and a resident of Moradabad, reported that when the meteor was noticed over Moradabad, fragments appeared to be falling off from it. He photographed the piece when it was brought into Moradabad (Plate 15) and found the weight to be nearly 23 lbs. After the photograph was taken, the District Magistrate had the meteorite sent to the railway workshops in that town for being cut up, so that by the time the Geological Survey of India could claim it, it had been cut into two halves right across the middle. Plate 16 shows the appearance of the pieces (in position relative to each other) as they are at present.

Enquiries made by the *Tahsildar* in charge of the Bahjoi area elicited only the following information, as given in a report made by him on the 13th August, 1934 :--

' In the village Chandankati Muazam where the piece of meteor fell, I examined the spot. There could be found no eye-witness, as the field in which the piece was found is far from habitation and it was dark on that night. It fell on the 23rd of July, 1934, between 9 and 10 o'clock at night. It was found by the cowherds Ghasi and Jagram who were grazing cattle. One of the points was projecting upwards four or five inches above the earth. They found it on the third day of its fall (*i.e.*, 25th July) at about 12 noon. They took it to the village, and after a day or two the *Chowkidar* took the piece to the Sub-Inspector of Police of Bahjoi who took it to headquarters.

The cowherds state that it was 10 or 11 seers in weight and looked like rusted old iron of black chocolate colour. They state that they saw a flash of light in the heavens at about 9 or 10 in the night due to which their eyes were dazzled, and further they saw nothing except that they heard three low sounds as if guns were fired, and it appeared as if something huge fell from the sky on the earth. On

inspecting the spot I could not trace any cracks, etc., as the place had been dug when the Sub-Inspector of Bahjoi visited the place.'

As mentioned above, the meteorite had been cut into two across the middle, before it was received by the Geological Survey. It has the usual battered appearance due to a series of broad shallow depressions on the surface. It is triangular in shape, measuring about 12 inches × 10 inches × 9 inches with a maximum thickness of 2½ inches. As received, the two halves weighed respectively 5,527·32 gms. and 4,795·22 gms. (total 10,322·54 gms.) After polishing and, etching, the larger piece weighed 5,509·67 gms. A small quantity of filings was also received but it is mixed with coarse emery powder. The specific gravity of one of the pieces was determined as 7·73.

The pieces are covered over with a thin black crust. The more prominent edges between the depressions have been worn to some extent, exposing the fresh white metal. This must have occurred mostly when it was handled in the workshops at Moradabad. On examination, the crust shows a series of fine raised lines crossing irregularly in different directions. In places, evidence of fusing and of incipient flow can also be seen. Occasionally the crust is seen to be composed of more than one layer. The edges are fairly well rounded, showing that the piece had been in flight for a while after it became a separate entity.

The sawn surface shows a few small patches of troilite, the rest being a uniform mass of nickel-iron.

The sawn surface of the heavier piece was levelled down so as to obtain a plane over a good part of it. It was then polished on leather with putty powder. The polished face was etched by immersing it in 6 per cent. nitric acid for 3½ minutes.[1] The appearance of the etched face can be seen in Plates 17 and 18. It shows that the meteorite belongs to the same class (Coarse Octahedrite) as the Samelia meteorite and has the same characteristics.[2] The kamacite bands are broad and coarse and cross in three directions. They are often bordered by thin streaks of bright tænite, and enclose some angular spaces which are also mainly kamacite.

The meteorite has been registered in the collection of the Geological Survey of India under No. 175 (iron meteorites).

[1] *Cf.* L. L. Fermor, 'Additional Note on the Samelia Meteorite', *Rec. Geol. Surv. Ind.*, LXV, pp. 161-162, (1931).
[2] L. L. Fermor, *ibid*, p. 162.

IV. EXPLANATION OF PLATES.

PLATE 14, FIG. 1.—Tirupati Meteorite (297), front view.

FIG. 2.—Tirupati Meteorite (297), back view.

PLATE 15.—Bahjoi Meteorite (175), before cutting (Photo : R. B. Connell).

PLATE 16, FIG. 1.—Bahjoi Meteorite (175), front view.

FIG. 2.—Bahjoi Meteorite (175), back view.

PLATE 17.—Etched face of Bahjoi Meteorite (175), ($\times 4{\cdot}2$).

PLATE 18.—Etched face of Bahjoi Meteorite (175), ($\times 2{\cdot}5$).

Ostrea (Crassostrea) gajensis FROM NEAR BARIPADA, MAYURBHANJ STATE. BY F. E. EAMES, B.SC., A.R.C.SC., F.G.S.

Palæontologist, Messrs. The Burmah Oil Co., Ltd.

(With Plate 19).

CONTENTS.

I. DESCRIPTION.

GENUS: OSTREA, LINNE, 1758.

(Genotype: *O. edulis*, Linne. Recent, see Children, 1823).

SUB-GENUS: CRASSOSTREA, SACCO, 1897.

(Genotype: *O. virginiana*, Gmelin. Recent, original designation).

Ostrea (Crassostrea) gajensis, Vredenburg.

(Pl. 19; Figs. 1-3).

Ostrea sp. P. N. Bose. 'Notes on the Geology and Mineral resources of Mayurbhanj' *Rec. Geol. Surv. Ind.*, XXXI, Pt. 3, p. 167, (1904).

Ostrea gajensis. Vredenburg. 'Descriptions of Mollusca from the Post-Eocene Tertiary Formation of North-West India; Gastropoda (in part) and Lamellibranchiata', *Mem. Geol. Surv. Ind.*, L, Pt. 2, p. 423, Pl. 24, Fig. 1, (1928).

The material consists of six specimens (Geological Survey of India, Registered No. K. 8/341), which were kindly lent to me by the Geological Survey of India. At the suggestion of the Director, Geological Survey of India, and by the courtesy of the Burmah Oil Co., Ltd., the results of the examination of the specimens are here placed on record.

Four of the specimens appear to me to be identical with *Ostrea (Crassostrea) gajensis*, Vredenburg; the remaining two specimens are not identifiable specifically, although one (a small fragment) shows ornament similar to that of *Ostrea (Crassostrea) gajensis*. In P. N.

Bose's paper the specimens are stated to have affinities with *Ostrea multicostata*, Deshayes and *Ostrea torresi*, Phillipi, but both these species belong to the sub-genus *Ostrea* (*sensu strictu*). The Baripada specimens have the large, massive ligament area of the sub-genus *Crassostrea*. The form and ornament agree well with Vredenburg's figures. The Nari species *Ostrea* (*Crassostrea*) *fraasi*, Mayer-Eymar, is related, but the Baripada specimens are larger and the lower valve is more massive (see Vredenburg, *loc. cit.*).

The specimens were found in yellowish and yellowish-brown limestones in the bed of the Barabalang river at Molia, two miles south of Baripada (22° 0′ 0″: 86°). *Ostrea* (*Crassostrea*) *gajensis* is recorded by Vredenburg (*loc. cit.*) from the Upper Gaj of North-West India, and also from Burma. Specimens from the Burmah Oil Co.'s collections from the Burma tertiaries all come from the Lower Miocene. It therefore appears very probable that these Baripada limestones are of Gaj (Lower Miocene) age.

II. EXPLANATION OF PLATE.

PLATE 19, FIG. 1.—*Ostrea* (*Crassostrea*) *gajensis*, Vredenburg. Left valve, external view. Regd. No. K8/341*a*. Near Baripada.

FIG. 2.—*Ostrea* (*Crassostrea*) *gajensis*, Vredenburg. Left valve, internal view (another specimen). Regd. No. K8/341*b*. Near Baripada.

FIG. 3.—*Ostrea* (*Crassostrea*) *gajensis*, Vredenburg. Right valve, internal view (another specimen). Regd. No. K8/341c. Near Baripada.

THE OCCURRENCE OF *Matonidium* AND *Weichselia* IN INDIA.

BY B. SAHNI, SC.D., F.R.S., *Professor of Botany, University of Lucknow.* (With Plates 20 to 24.)

CONTENTS.

I.—INTRODUCTION.

The fossils described in this paper were collected by Dr. A. M. Heron, Director, and Mr. P. N. Mukerjee, Extra Assistant Superintendent, Geological Survey of India, from the Ahmednagar sandstone in a small rocky knoll, two miles north by east of Ahmednagar (Himatnagar; 23° 36′: 73° 2′; sheet 46 A/14) near where the sandstone rests unconformably upon the granite.

The name of the town was changed from Ahmednagar to Himatnagar after it became the capital of Idar State, and the change avoids confusion with the other Ahmednagar in the Bombay Presidency.

The locality was first noted by Mr. C. S. Middlemiss,[1] but he was able to obtain only dubious plant remains, entirely unrecognisable. Dr. Heron examined the other locality, Berna, alluded to by Middlemiss, but found none. In R. B. Foote's 'Geology of Baroda' and Sambasiva Iyer's 'Sketch of the Mineral Resources of the Baroda State', the Ahmednagar sandstone was regarded as Eocene. Middlemiss, by analogy with the Dhrangadra freestone[2] of north-east Kathiawar (Umia stage, Upper Gondwana, Jurassic or Cretaceous), the Songir sandstone[3] of Baroda (marine Cretaceous) and possibly the Barmer sandstone[4] of western Rajputana[5], considered it to be Cretaceous.

[1] *Mem. Geol. Surv. Ind.*, XLIV, Pt. 1, p. 142, (1923).
[2] Fedden, F., *Mem. Geol. Surv. Ind.*, XXI, Pt. 1, p. 63, (1884).
[3] Sambasiva Iyer, 'Sketch of the Mineral Resources of the Baroda State'.
[4] Blanford, W. T., *Rec. Geol. Surv. Ind.*, X, pp. 11, 18, (1877).
[5] La Touche, T. D., *Mem. Geol. Surv. Ind.*, XXXV. p. 33, (1902).

The matrix is a coarse, brown or pink coloured ferruginous rock which breaks up very irregularly under the hammer, so that only fragmentary specimens of the fossils can be obtained. It has, however, been possible to identify with certainty the two Wealden genera *Matonidium* and *Weichselia,* neither of which was previously known from India. This small collection therefore affords the first evidence of the existence of a Wealden flora in this country.

My best thanks are due to Dr. A. M. Heron for kindly placing this interesting collection at my disposal for description. To Professor Sir A. C. Seward, F.R.S., I am grateful, as on many previous occasions, for his kindly reading the manuscript and for valuable suggestions. My sincere thanks are also due to Mr. W. N. Edwards for important remarks concerning the indeterminate fragments. The photographs were made by my assistant Mr. K. N. Kaul, M.Sc. To my wife I owe valuable help in drawing the restoration of *Matonidium indicum* reproduced in Plate 24.

II.—DESCRIPTION.

Matonidium indicum, sp. nov.

(Pl. 20, figs. 1-7 ; Pl. 21, figs. 1-6 ; Pl. 22, figs. 1-4 ; Pl. 24).

A species closely allied to *M. goepperti,* Schenk[1] but differing chiefly in the fact that the pinnae or "rays" are fused below into an incompletely funnel-shaped lamina at the top of the petiole. In one of Schenk's figures of *M. Goepperti* (Pl. XLII, fig. 1) there is a faint suggestion of fusion of the pinnae at the base, and Mr. W. N. Edwards informs me that one of the Yorkshire specimens in the British Museum shows a 'slight fusion at the base, but not more than a millimetre—certainly not a funnel'. The funnel-like expansion therefore constitutes a well-marked diagnostic feature of the Indian species.

Plate 20, figs. 1-2 and 6-7 are natural size photographs of counterparts of two fronds. In figs. 1-2 the lower portions of several radiating pinnae are seen to converge towards the top of the petiole. The pinnules diminish in length proximally, the falcate character at the same time becoming less pronounced. The lowermost pinnules are reduced to short rounded lobes. In fig. 2 a portion of the funnel-shaped expansion is preserved at *f.* Figs. 6 and 7 show a similar

[1] Schenk, A., *Palæontographica,* Vol. XIX, (1871).

specimen seen from the adaxial side, where the funnel is incomplete. This fragment is important because it shows the characteristic pedate mode of branching and the thickened adaxial rim of the funnel where it dips towards the petiole in a broad V-shaped incision. The pinnules are not preserved but their points of attachment are clearly marked on some of the rays in fig. 7. In fig. 3 (enlarged about two diameters in fig. 4) the funnel is seen from the abaxial side, with the scar of the petiole placed in such a position as to indicate that the basal margin of the lamina must have been continuous round the top of the petiole on the adaxial side. On either side of the median ray (the central ray of fig. 4) which lies in the continuation of the main rachis, there must have been at least ten lateral rays. The frond was no doubt built on a monopodial plan, but a view from the adaxial side gives a deceptive appearance of dichotomy. Fig. 5 is a lateral view of the funnel.

Plate 21, fig. 1 is a view from the top of the funnel, looking down into the cavity left by the decayed petiole. On the right several rays are indistinctly preserved, running almost horizontally outwards. In fig. 2 is shown the counterpart of this specimen, in which one of the rays is preserved for a length of about 14 cm. At *r* the longitudinally ribbed character of the rachis is clearly shown, but this may be a concealed feature shown up by the decay or shrinking of the softer tissues covering the vascular bundles. The main petiole seems to have been flattened at the top (*see* fig. 1), and the smooth outline of the cavity left by it in this specimen indicates that the ribs are a deep-seated feature. Numerous ribbed fragments like the one shown in fig. 4 are found among the remains of the pinnae (*see* Plate 20, figs. 1, 6). Similar axes, but of much greater thickness, have been attributed by Edwards[1] to *Weichselia reticulata.* Although this species is also represented in our collection, the *Matonidium* is far more abundant, and I am inclined to refer these thinner axes to the latter plant.

The characters of the markedly convex pinnules are well seen in Plate 21, figs. 5, 6, and Plate 22, figs. 1-4. The oblong or elliptical sori, which are placed transversely in a double row on each pinnule, are marked with an elongated central depression, as in *M. goepperti.* As in that species, the sori extend to the very tip of each pinnule. Our Plate 22, fig. 3 may be compared with Prof. Seward's figure of the

[1] Edwards, W. N., *Ann. Mag. Nat. Hist.*, Ser. 10, X, p. 406, (1932).

latter species.[1] It has not been possible to demarcate the indusium, as the matrix is very coarse. For the same reason I have not been able to obtain any spores, nor to ascertain the form or structure of the sporangium. Viewed from above each pinnule shows a deep groove along the midrib and a similar groove marks the position of the main rachis of the pinna. In transverse fractures the pinnules are seen to be strongly revolute (Plate 21, fig. 6). In this sketch the blank parts show the decayed tissues of the pinnule, seen as a cavity in the matrix, which is shaded. The dotted line indicates that the adaxial groove along the midrib was not so deep in the actual pinnules as might appear from their mode of preservation as moulds. Nor was the lamina at all so thick as a view from above might appear to indicate. At the same time it seems clear that the texture was coriaceous, because the form of the pinnules has been left intact inspite of the coarse nature of the matrix.

The sterile pinnules (Plate 20, fig. 2 s) are not so thick as the fertile, but like these they were probably coriaceous. The furcate veins are clearly seen in Plate 22, fig. 2.

Diagnosis.—Petiole adaxially flattened, tapering upwards, and expanding at the top into an incompetely funnel-shaped lamina about 1·5 cm. in diameter from which at least 21 pinnae radiate: that is, at least 10 on either side of the median ray. Base of lamina continuous over the adaxial side of the petiolar apex (almost peltate attachment). Pinnae at least 15 cm. long; pinnules thick, coriaceous, with a deep adaxial groove marking the midrib. Proximal pinnules short and rounded, the rest more or less strongly falcate, diminishing in length towards the apex of the pinna; margin revolute, veins furcate. Sori elliptical, contiguous in two rows on each pinnule, with a transversely elongated central depression as in *M. goepperti*. (G. S. I. Type Nos. 15,778 to 15,788).

Weichselia reticulata.

(Pl. 22, fig. 5 ; Pl. 23, figs. 1-7).

This widely distributed and probably xerophytic fern is represented only by a few small fragments of sterile pinnae, but there can be no doubt of its identity. The bipinnate character of the frond is seen in Plate 22, fig. 5. The thick and convex, elliptical

[1] Seward, A. C., Brit. Mus. Catalogue, p. 76, fig. 7a, (1900).

pinnules, sometimes slightly falcate, are attached by the full width of the base. As seen from the adaxial surface they show a deep median groove which stops short of the broadly rounded apex. The characteristic reticulate venation, preserved only in a few places, is well seen in Plate 23, figs. 5, 6. The 'butterfly' position of the pinnules, described by several previous authors, is not seen in our material, nor is it a constant feature of the species. But the paired scars of the vascular bundles in Plate 22, fig. 5 show clearly that the pinnules were placed close to the median line of the rachis, no doubt on the adaxial side. This figure also shows the characteristic sweeping curve in the lower part of the secondary rachis. Another feature of *Weichselia* is the reflexed basal pinnules. Plate 23, figs. 3, 4 show two reflexed pinnules, but it is not possible to say whether they are basal in position.

The ribbed axes seen in Plate 20, figs. 1, 6, and Plate 21, fig. 4, recall those assigned by Edwards to *Weichselia* but they are not nearly so broad, and I have given reasons to attribute them to *Matonidium*.

The discovery of *W. reticulata* in India considerably extends the distribution of this species and constitutes important evidence in support a Lower Cretaceous age for the Ahmednagar (Himatnagar) sandstone; although, as Edwards has pointed out, the species cannot be regarded as decisive of a particular horizon.

Gothan has suggested that *Weichselia reticulata* was most probably a xerophytic fern inhabiting sand-dunes. In the present case there is no evidence of desert conditions. According to a report kindly supplied by the Director of the Geological Survey of India the matrix is a coarse-grained false-bedded sandstone deposited in shallow water in a river bed or on the shores of a lake, though possibly with sand-hills in the vicinity.

Sphenopteris (? *Coniopteris*) sp.

(Pl. 23, fig. 8.)

These sterile fragments of a sphenopterid leaf show a number of cuneate segments attached at an acute angle and supplied by forked veins. Possibly they represent a new species but the material is quite insufficient to show the variations. A slight comparison may be made with *S.* (*Coniopteris*) *burejensis*, Zalessky sp., a Jurassic

species from Amurland described by Professors Zalessky[1], Seward[2] and Kryshtofovich[3]; but, as Mr. Edwards observes (in a letter to me), similar sphenopterids are also known from the Cretaceous.

? *Sphenopteris* sp.

(Pl. 23, fig. 9.)

This solitary specimen shows a number of narrow pinnules placed obliquely upon a rachis. Each pinnule has a slightly sinuous margin and faintly shows a furcate venation. Mr. Edwards suggests that this fragment might belong to *Cladophlebis dunkeri.*

? *Thinnfeldia* sp.

(Pl. 23, fig. 10.)

The fragment of fern-like pinnae with simple or furcate veins, here shown three times enlarged, recalls some species of *Thinnfeldia*[4], but it would be unsafe to attempt to identify them with any known plant without further data. Edwards would place it provisionally under *Cladophlebis* and suggests comparison with Schenk's figure of '*Alethopteris*' *huttoni*[5].

III.—DISCUSSION.

The chief interest of this small flora lies in the fact that it extends the known geographical distribution of two widespread genera of xerophytic ferns, and in the evidence which it affords of the geological age of the Ahmednagar (Himatnagar) sandstone. The age of the flora cannot be fixed with absolute certainty, but there seems very little doubt that it is Lower Cretaceous and it corresponds most probably to the Wealden.

[1] Zalessky, M. D., *Bull. Com. Géol. St. Pétersb.*, t. 23, (1904).
[2] Seward, A. C., *Mém. Comité Géol.* Livr. 81, p. 22, Pl. 1, figs. 1-5, (1912).
[3] Kryshtofovich, A. N., *Trav. Mus. Géol. Pierre le Grand près l'Acad. Imp. Sci.* t. VIII, p. 85, (1914).
[4] Seward, A. C., *Mém. Comité Géol.* N. S., Livr. 38, pl. 1, fig. 11, (1907). *id.*, *Trans. Roy. Soc. Edinb.*, 47, p. 675, (1911); Halle, T. G., *Wiss. Ergeb. Schwed. Süd-Pol. Exped.* 1901-1903. Bd. III, p. 45, (1913).
[5] Schenk, A., *Palæontographica*, Vol. XIX, Pl. XXIX, fig. 1, (1871).

The genus *Matonidium* is said to range from the Middle Jurassic to the Cretaceous[1]. The Cenomanian species *M. wienseri*, described by Krasser[2] from Moravia has quite recently been made the type of a new genus, *Matoniella*, by Hirmer and Hoerhammer[3] in an important monograph on the recent and fossil Matoniaceae. The older and better known species, *M. goepperti*, Schenk, is known from the Inferior Oolite of Yorkshire[4], from the Kimmeridgian (Upper Jurassic) of Sutherland[5] and from the Wealden (Lower Cretaceous) of Germany[6], Belgium[7] and England.[8] It has also been recorded from the Mesozoic of Russia.[9]

The Indian species, being new, cannot strictly be used as an age index but, as stated, it is very closely allied to, though not identical with, *M. goepperti* (=*M. althausii*, Dunker sp.), the chief difference from the latter being the much greater development of a funnel at the base of the pinnae.

As for the *Weichselia*, there seems no doubt of its specific identity with *W. reticulata* as that species is generally defined, that is, including its variants which, at least at present, cannot be satisfactorily distinguished from the type. This is a much more widely distributed plant, and it is also a better index to age than the *Matonidium*. All the known records lie within the Cretaceous and most of them in the Wealden, of which it is regarded as a leading species. As Edwards[10] has justly pointed out, however, the species ranges through all the stages from the Neocomian to the Cenomanian, hence conclusions as to the age of a stratum cannot be safe if based solely upon the occurrence of this species. For a critical review of *W. reticulata* from all aspects (structure and affinities, geographical distribution, geological range, ecology, etc.) the reader should refer to the important paper by Edwards just cited, where most of the literature is given. In strata regarded as Lower Cretaceous this plant has

[1] Potonié, H. und Gothan, W., Lehrbuch der Palæobotanik, p. 43, (1921).

[2] Krasser, F., *Beitr. Pal. Geol. Oest.-Ung. u. d. Orients.* Bd. 10, Heft 3, (1896).

[3] Hirmer & Hoerhammer, *Palæontographica*, Vol. LXXXI, Abt. B., p. 47, (1936).

[4] Seward, A. C., Brit. Mus. Catalogue, p. 76, (1900).

[5] Seward A. C., *Trans. Roy. Soc. Edinb.*, 47, p. 662, (1911).

[6] Schenk, A., *Palæontographica*, Vol. XIX, (1871).

[7] Seward A. C., *Mém. Mus. Roy. d'Hist. Nat. Belg.*, 1, p. 10, (1900); *id.*, Fossil Plants, Vol. II, p. 361, (1910); *id.*, Wealden floras, *Hastings and E. Sussex Nat.* 2 (3), p. 133, (1914).

[8] Seward, A. C., Brit. Mus. Catalogue, p. 62, (1894).

[9] Kryshtofovich, A. N. and Prinada., Mesozoic flora of U. S. S. R., p. 49, fig. 8, (1934).

[10] Edwards, W. N., *Ann. Bot.* 47, (186), p. 339, (1933).

been recorded from England[1], Belgium[2], France[3], Germany[4], Austria, Sweden, Ussuriland[5], Japan, North America, Peru[6], and probably Venezuela; also from Syria, Transjordania[7], Darfur[8] and with some doubt from the Sinai peninsula[9]. Among the few younger records the most important is that from Egypt[10] (Baharia Oasis) where this fern is said to be associated with a Lower Cenomanian fauna. Other localities in Egypt from which *Weichselia* has been recorded are shown in a map published in a recent paper by Professor Seward[11], which contains important observations on the association of this fern with dicotyledons.

The remaining species in the flora are all represented by small fragments; these do not seem to be inconsistent with a Lower Cretaceous age, but their stratigraphical value cannot be properly assessed till their affinities are better known.

We are thus left with only two species from which to draw whatever conclusions we can as to the age of the beds. Taking the evidence for what it is worth, the probability is strongly in favour of a Lower Cretaceous age. It would be rash to try to fix the horizon more precisely, although *W. reticulata* is highly characteristic of the Wealden, where *Matonidium* also occurs.

The only other Indian flora referred to the Lower Cretaceous period is the (Upper Gondwana) Umia flora of Cutch. This flora was

[1] Seward, A. C., Brit. Mus. Catalogue, p. 113, (1894); *id.*, Fossil Plants, Vol. II, p. 494, (1910); Stopes, M. C., Brit. Mus. Catalogue, p. 3, (1916).

[2] Seward, A. C., *Mém. Mus. Roy. d'Hist. Nat. Belg.*, 1, p. 20, (1900); Bommer, C., *Bull. Soc. Roy. Bot.* Bruxelles, Vol. 47, (1911).

[3] Carpentier, A., *Mém. Soc. Géol. Nord.* t. X, Lille, p. 122, (1927).

[4] Stiehler, A. W., *Palæontographica*, Bd. V, (1858); Hosius und von der Marck, *Palæontographica*, Vol. XXVI, p. XLIII, (1880); Gothan, W., Abbild. u. Beschreibungen. Lief. 7, (1910); *id.*, *Jahrb. preuss. geol. Landesanstalt*, 43, (1921); Potonié, H. und Gothan, W., Lehrbuch der Palæobotanik, p. 44, (1921); Schuster, J., *Neues Jahrbuch Min. Geol. Palæontol.* Band 64 (B), p. 74, (1930).

[5] Kryshtofovich, A. N., Geology : The Pacific Russian Investitions. (Published by the Acad. of Sciences, U. S. S. R., Leningrad.), pp. 61, 62 (Upper Nikan Ser = Wealden), (1926); *id.*, *Bull. Com. Géol. Leningrad*, Vol. XLVIII, (1929); *id.*, *Amer. Journ. Sci.*, XVIII, p 524, (1929).

[6] Neumann, R., *Neues Jahrb.* XXIV, (1907); Zeiller, R., *C. R. de l'Acad. Sci.*, t. 150, (1910); Seward A. C., *Hastings and E. Sussex Nat.* 2 (3), p. 137, (1914).

[7] Edwards, W. N., *Ann. Mag. Nat. Hist.*, Ser. 10, 4, p. 396 (Syria), p. 403 (Transjordania), (1929).

[8] Edwards, W. N., *Quart. Journ. Geol. Soc.*, 82, (1926); *id.*, *Ann. Mag. Nat. Hist.*, Ser. 10, X., (1932). This locality lies at Lat. 13° 30′ N., Long. 26 E.

[9] Edwards, W. N., *Ann. Mag. Nat. Hist.*, Ser. 10, X, p. 406, (1932).

[10] Hirmer, M., *Abh. bay. Akad. Wiss.* XXX (3), (1925); see also Seward, A. C., *Geol. Mag.*, Decade V, 4, p. 255, (1907).

[11] Seward, A. C., Leaves of Dicotyledons from the Nubian sandstone of Egypt. Geol. Survey of Egypt, pp. 4-5, (1935).

formerly regarded as Jurassic, but as the plant-bearing beds are said to be interstratified with marine deposits regarded as homotaxial with the Wealden of Europe, the flora would seem more probably to be of Lower Cretaceous age[1]. However, till the Umia flora has been critically revised, the palæobotanical evidence concerning its age cannot be regarded as decisive. So far as I know neither *Weichselia* nor *Matonidium* is represented in Cutch.

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[1] Cotter, G. de P., *Rec. Geol. Surv. Ind.*, XLVIII, p. 32, (1917); Sahni, B. *Proc. Asiat. Soc. Beng.*, (New Series), XVII (iv), pp. clxvi, (1922).

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V.—EXPLANATION OF PLATES.

All the figures are from untouched photographs and, unless otherwise stated, are of the natural size.

PLATE 20, FIGS. 1, 2.—***Matonidium indicum***, sp. nov. Counterparts of a portion of the frond, showing proximal parts of several 'rays'. In fig. 2 a portion of the funnel-shaped expansion at the top of the petiole is preserved at *f*, and a few sterile pinnules at *s*. [G. S. I. Type No. 15, 778.]

FIGS. 3, 4.—*Matonidium indicum*, sp. nov. Funnel-shaped expansion, with basal parts of 'rays', seen from the dorsal side. The point of attachment of the petiole is preserved. Fig. 4, × *ca* 2. [G. S. I. Type No. 15, 779.]

FIG. 5.—*Matonidium indicum*, sp. nov. The same, in lateral view; the adaxial side is towards the left; the arrow indicates the scar of the petiole. [G. S. I. Type No. 15, 779.]

FIGS. 6, 7.—*Matonidium indicum*, sp. nov. Counterparts of a frond, showing the 'funnel' from the adaxial side. Note the pedate mode of origin of the rays. [G. S. I. Type No. 15, 780.]

PLATE 21, FIG. 1.—*Matonidium indicum*, sp. nov. Mould of a funnel-shaped expansion, seen from above, with basal ends of 'rays'. The elliptical hole in the middle is continued downwards as a canal in which the petiole lay. On the right a few 'rays' are preserved. × 1½. [G. S. I. Type No. 15, 781.]

FIG. 2.—*Matonidium indicum*, sp. nov. Counterpart of the above specimen, showing one of the rays preserved for a length of 14 cm. The ribbed character of this ray is seen at *r*. The 'funnel' at the extreme left of fig. 2 is shown enlarged in fig. 3. Slightly reduced. [G. S. I. Type No. 15, 781.]

FIG. 3.—*Matonidium indicum*, sp. nov. Part of the funnel-shaped expansion from the same specimen, showing bases of some of the 'rays'. × 2½. [G. S. I. Type No. 15, 781.]

FIG. 4.—*Matonidium indicum*, sp. nov. Ribbed axis expanding at the lower end, probably a petiole of this species. Similar fragments are seen in Plate 20, figs. 1 and 6. [G. S. I. Type No. 15, 782.]

FIG. 5.—*Matonidium indicum*, Basal part of a fertile pinna. [G. S. I. Type No. 15, 783.]

FIG. 6.—*Matonidium indicum*, sp. nov. Transverse section of a pinnule. × *ca*. 15. [G. S. I. Type No. 15, 784.]

PLATE 22, FIG. 1.—*Matonidium indicum*, sp. nov. Part of a fertile pinna seen from the upper side. × 2. [G. S. I. Type No. 15, 785.]

FIG. 2.—*Matonidium indicum*, sp. nov. Part of a fertile pinna seen from the upper side. × 3. [G. S. I. Type No. 15, 786.]

FIG. 3.—*Matonidium indicum*, sp. nov. Several fertile pinnules showing the lower (sporangiferous) surface. × 7. [G. S. I. Type No. 15, 787.]

FIG. 4.—*Matonidium indicum*, sp. nov. Part of a fertile pinna seen from the upper side. [G. S. I. Type No. 15, 788.]

FIG. 5.—*Weichselia reticulata.* Mould of main rachis with parts of secondary rachises attached, showing paired scars of vascular strands of pinnules. [K33/730.]

PLATE 23, FIG. 1.—*Weichselia reticulata.* [K33/731.]

FIG. 2.—*Weichselia reticulata.* [K33/731.]

FIG. 3.—*Weichselia reticulata.* [K33/733.]

FIG. 4.—*Weichselia reticulata.* × 3. [K33/731.]

FIGS. 5, 6.—*Weichselia reticulata.* Pinnules showing reticulate venation. fig. 5, × 5; fig. 6, × 12. [K33/735.]

FIG. 7.—? *Weichselia reticulata.* Distal part of a pinna seen from below. × 2. [K33/730.]

FIG. 8.—*Sphenopteris* sp. Fragments, × 3. [K33/730.]

FIG. 9.—? *Sphenopteris* sp. Fragments of frond. [K33/736.]

FIG. 10.—? *Thinnfeldia* sp. Fragment of frond. × 3. [K33/736.]

PLATE 24.—*Matonidium indicum,* sp. nov. Reconstruction of a frond as seen from the abaxial side.

ON THE SUPPOSED CRETACEOUS CEPHALOPODS FROM THE RED BEDS OF KALAW AND THE AGE OF THE RED BEDS. BY M. R. SAHNI, M.A. (CANTAB.), D.Sc. (LOND.), D.I.C., *Assistant Superintendent, Geological Survey of India.* (With Plate 25).

CONTENTS.

I.—INTRODUCTION.

In a recent communication addressed to the Director, Geological Survey of India, Dr. Coggin Brown expressed doubts regarding the determination of two specimens from the Red Beds of Kalaw, discovered by Dr. Fox in 1929 and later identified as *Baculites* sp. *vagina* (?) (No. K24/866) and *Turrilites* sp. *cunliffeanus* (?) (No. K24/865) by Dr. Cotter. Referring to these specimens Dr. Fox wrote[1]. 'Unfortunately the material was exceedingly fragile and easily crumbled to pieces. In spite of the greatest care only two specimens survived the train and sea journeys to Calcutta........The specific determinations are of course open to emendation, but Dr. Cotter was in no doubt that these cephalopods were similar to those in the Trichinopoly beds of the Madras Coromandel coast, which are Upper (Ariyalur) to Middle (Utatur) Cretaceous in age.'

[1] *Rec. Geol. Surv. Ind.*, LXIII, Pt. 1, p. 184, (1930).

II.—CONDITIONS OF DEPOSITION OF THE RED BEDS OF KALAW AND THE NAMYAU SERIES.

In Dr. Brown's opinion, the Mesozoic beds of the Southern Shan States are sub-continental or lagoonal and locally, as at Kalaw, continental. He therefore expresses surprise at the occurrence of cephalopods in the Red Beds at Kalaw. The writer made a careful search in this locality on more than one occasion, but was unable to find any trace of organic remains. He was, however, much impressed, during the course of his work in the Northern and more recently in the Southern Shan States, by the lithological similarity between the Namyau series of the Northern Shan States (which, however, contains limestone bands) and the Red Beds of Kalaw. The Namyau series, composed of reddish or purplish sandstones and shales and interstratified fossiliferous limestone bands, are, according to La Touche[1], probably of a continental character, being deposited 'along the shore of a shallow sea extending northward into China'. However, in the writer's opinion, the absence of cephalopods in the Namyau series has no relation to the depth of the sea in which these beds were deposited—the determining factor was probably an ecological or geographical one, for the association of ammonites with brachiopod forms (almost exclusively species of *Holcothyris* and *Burmirhynchia*) present in the limestone bands interstratified with the Namyau series would not be at all surprising. In regard to the Red Beds (Namyau series) of the Northern Shan States, then, the term 'shallow water marine' perhaps more aptly describes the conditions of deposition than 'continental'.

III.—INORGANIC NATURE OF THE KALAW SPECIMENS.

In view of the fact that the Cretaceous age of the Red Beds of Kalaw was deduced solely from only two poorly preserved and doubtful specimens, it was considered desirable that the specimens should be re-examined and their determinations established, since the writer did not think that they were cephalopods. This was done by Dr. L. F. Spath of the British Museum (Natural History), London, who very kindly examined the specimens and not only agreed with the writer's conclusions that they were not cephalopods, but went a step further and declared that specimen No. K 24/866

[1] *Mem. Geol. Surv. Ind.*, XXXIX, p. 308, (1913).

(the one which showed traces of structure that could be mistaken for organic) was also of inorganic origin. He wrote:

'I have no hesitation in saying that they (the specimens) are not even organic, leave alone Cephalopods..........and it seems incomprehensible how these identifications as *Baculites* and *Turrilites* (and even species) could ever have been made '[1].

IV.—DESCRIPTION.

A brief description of the specimens may be given.

Specimen No. K 24/865 hardly deserves a description. It is a soft, brick-red or purplish crumbly sandstone with tubular ferruginous concretions and does not betray the least trace of organic structure. The other specimen (No. K 24/866), which was probably cylindrical, is incomplete at one end. The portion preserved is about 3½ inches in length and gently tapers towards the broken extremity. Two slight depressions at the complete end divide it into three lobes, of which the middle one is acute and fairly well defined. A sharp ridge, probably of secondary origin, due to pressure, runs 'dorsally' along one side of the specimen. The specimen is 'dorsally' convex, and apparently segmented (Pl. 25, figs. 1-3), a character which may be compared with segmentation as seen in crustaceans or may even be vaguely reminiscent of costation as in cephalopods. It was probably the latter character which led Dr. Cotter to compare this specimen with *Baculites vagina*, for on the slightly weathered surface of the figured specimen of that species[2] the ornamentation appears somewhat similar, though it could not possibly be mistaken for it. Near the unbroken extremity of the specimen from Kalaw certain markings give the impression of lobes and saddles but they are so obviously of a superficial nature that they need not even be considered.

V.—AGE OF THE RED BEDS.

As a correlation between the Mesozoic beds of the Northern and Southern Shan States, based upon and undoubtedly influenced by the previous determinations of these specimens as Cretaceous cephalopods, has been provisionally proposed by Dr. Fox[3], this will need revision. Thus we are now unable to assign confidently a Cretaceous age to the Red Beds of Kalaw, and the correlation of the Namyau

[1] In a letter addressed to the Director, Geological Survey of India.
[2] *Pal. Ind.*, Ser. I and III., Vol. I, Pl. XCI, fig. 4, (1866).
[3] *Rec. Geol. Surv. Ind.*, LXIII, Pt. 1, Table on p. 195, (1930).

shales (=upper part of the Namyau series, according to Buckman[1]) of the Northern Shan States with the Cretaceous rocks of Southern India becomes *ipso facto*, untenable. It may, however, be stated that in the area surveyed by the writer, this division, of the Namyau series into a lower and an upper division as suggested by Buckman has not been recognised and in the writer's opinion cannot be maintained.

Recently Mr. E. L. G. Clegg has discovered an argillaceous limestone containing *Orbitolina* at a locality one mile S. W. by W. of Kawdaw (23° 42′ : 96° 42′), sheet No. 93A/10, which stamps the age of these beds as Cretaceous. Certain other beds mapped by him in the same area are lithologically similar to those of the Assam Cretaceous which are placed in the upper division of the system by Spengler[2]. This would lend additional support to the view that the Kalaw Red Beds, which are lithologically quite different, may not be of Cretaceous age. The fossils collected by Mr. Clegg from these beds are now under investigation by the writer, but our determination of *Orbitolina*—a genus which is not supposed to occur in rocks younger than the Cenomanian—settles at least the fact of their Cretaceous age. This is of importance since very little is known about the occurrence of Cretaceous rocks in Burma. For a more precise opinion on the age of these fossils and of the containing beds, the results of their determination may be awaited.

Since the question of the age of these beds is under consideration, it is not proposed to give any provisional classifications here.

VI.—EXPLANATION OF PLATE.

[All photographs are of natural size.]

PLATE 25, FIG. 1. 'Dorsal' view of specimen No. K 24/866 identified as *Baculites* sp. *vagina* (?) by Dr. G. de P. Cotter and now recognised as of inorganic origin. Note the segmentation and 'dorsoventrally' running ridge of probable secondary origin.

FIG. 2. Same specimen, showing trilobed character of the unbroken extremity.

FIG. 3. Same specimen. Lateral view, showing 'dorso-ventral' ridge and acute middle lobe of the preserved end of the specimen.

[1] *Pal. Ind.*, N. S., Vol. III, Mem. No. 2, p. 215, (1917).

[2] Spengler, E., 'Contributions to the Palæontology of Assam', *Pal. Ind.*, N. S., Vol. VIII, Mem. No. 1, p. 65, (1923).

CONTRIBUTIONS TO THE GEOLOGY OF THE PROVINCE OF YUNNAN IN WESTERN CHINA. 9. THE BRACHIOPOD BEDS OF LIU-WUN AND RELATED FORMATIONS IN THE SHAN STATES AND INDO-CHINA. BY J. COGGIN BROWN, O.B.E., D.Sc. (DUNELM), F.G.S., F.R.A.S.B., M.I.MIN.E., M.INST.M.M. (With Plates 26 and 27.)

CONTENTS.

I. INTRODUCTION AND EARLIER WORK.

Introduction.

Brief accounts of the rocks and structures seen in the Salween valley, where it is crossed by the main trade route over western Yunnan, between Têng-yüeh (25° 2′ : 98° 33′) and Ta-li Fu (25° 42′ : 100° 12′), have been given by L. von Loczy (1893), J. Coggin Brown (1916), J. W. and C. J. Gregory (1925) and W. Credner (1931), but they all failed to recognise the presence of Mesozoic rocks there and it was not until the publication, in 1927, of Dr. Cowper Reed's determinations of my own fossil collections, that the occurrence of these unsuspected strata was made known. This is perhaps not surprising when it is remembered that the well-known Mesozoic Napeng fauna, the exact position of which is still by no means settled, was once thought to be of Devonian age, while the Brachiopod Limestones of the Laos have, at various times, been regarded as possessing Palaeozoic, Liassic and Middle Jurassic affinities before their recent attribution to the Upper Trias.

Old metamorphic rocks of the Kao-liang series build the high western boundary wall of the Salween valley. On the opposite side lie the Lower Ordovician beds of Pu-piao. The intervening twelve miles, in which there is a descent of 4,600 feet to the Salween bridge at 2,200 feet above sea level, followed by a rise of 2,300 feet to the Pu-piao plain, consist of exceedingly contorted country, the involved structure of which cannot possibly be determined by a single traverse and which will not be interpreted until it is mapped on a large scale.

Loczy's observations.

Loczy admitted the uncertainty of his descriptions of this complicated region. Approaching it from the east and after leaving the Lower Ordovician rocks, he noted that the lower parts of the hills surrounding the Pu-piao basin were made up of limestones and diabase tuffs, dipping in a westerly direction. Above these, near Fang-ma-ch'ang, some four miles north-west of Pu-piao, and at the head of the small, south-westerly flowing tributary down which the track makes its steep descent to the Salween, are bryozoan limestones from which he obtained a *Fenestella* related to *F. schumardi*, Bront., and from which my own collections yielded *Fenestella sinensis*, Reed, *F. yabei*, Reed, *Polypora* cf. *koninckiana*, Waag. and Pichl. and *Rhombopora* sp., denoting a Permo-Carboniferous if not a Permian age. Loczy also mentioned the succession of very disturbed, yet in places vertical, brecciated limestone bands, diabases, tuffs, brown sandstones and calcareous marls which follows lower down. The strike was clearly from north to south and the correlation of the igneous rocks with the Carboniferous appeared probable to him. He also saw that many of the limestones are siliceous and enclose quantities of tuff. The left bank of the Salween he found bounded by limestone, while the eastern slopes of the Irrawaddy-Salween divide showed shaly limestones, phyllites, mica schists and quartzites which seemed to be folded into gneissose granite.[1]

W. Credner's traverse.

W. Credner was more concerned with observations of land forms and the processes which have produced them than with the problems of stratigraphy; nevertheless, he drew attention to the phyllites, slates and granites of the Irrawaddy-Salween divide and his map shows the valley of the latter occupied by Palaeozoic limestone in straight contact, along

[1] Die Wissenschaftlichen Ergebnisse der Reise des Grafen Bela Szechenyi in Ostasien Vol. 1, pp. 762-770, (1898).

the river bed, with metamorphic rocks, followed on the west by gneisses and granites. Credner remarked that the great extent of the Permo-Carboniferous formations is proved not only by their fossils, but also by the frequent occurrence of the basaltic and melaphyric eruptive rocks which are connected with them; in addition, he noticed that alternations of limestones and basic eruptives with subordinate shales and sandstones stretch across the valley as far as the eastern slopes of the divide. He regarded the whole area as a complex of steeply folded and generally isoclinal structures, in which much has still to be done by way of detailed stratigraphical studies, before it can be analysed.[1]

J. W. and C. J. Gregory's results.

Allowing for the fact that the late Prof. Gregory's notes, as well as my own, were made while travelling hastily across a region in which the sequence is unusually varied, incompletely exposed and thoroughly deranged, it is remarkable that they have not more differences.[2] He noted that on the Irrawaddy-Salween divide, the gneissic foundation disappeared beneath the green schists, quartzites, phyllites and slates of my Kao-liang series. He accepted the validity of this series, regarding it as corresponding to one of the later pre-Cambrian divisions somewhat earlier than the Torridonian or Keweenawan.[3] On the descent to the Salween he saw the thin bands of crystalline limestone which it occasionally contains and the pegmatite dykes which sometimes intrude it. The brecciated limestone at the bridge, which I regard as Devonian, he thought might be of earlier date. In the tributary valley up which the track ascends, we have both recorded the rapid alternations of sandstones, shales and limestones with their associated bands of basic rock. He described how they have been thrown into a series of sharp folds and fractured by faults, both normal and horizontal, as well as by at least one thrust plane. Some of the diabases, he considered, were intrusive, but my own notes emphasize the tuffaceous character of the shales and the contemporaneity of some of the igneous sheets, which is confirmed by the presence of abundant volcanic matter in the limestone bands near Fang-ma-ch'ang.

On Prof. Gregory's map the rocks in the lower part of the Salween valley are shown as belonging to the Kao-liang series and the

[1] Yunnan Reise des Geographischen Institute der Sun-yatsen Universität. Teil II. Beobachtungen zur Geologie und Morphologie, pp. 65-67, (1931).
[2] *Phil. Trans.*, Ser. B., Vol. 213, pp. 176-178, 232-234, (1925).
[3] *Ibid.*, p. 219.

remainder to the Carboniferous, but it appears from his notes that another interpretation had occurred to his mind. This is indicated by his statement regarding the abrupt endings of the Minchia series against the Kao-liang series, north of the Salween bridge.[1] His Minchia series includes what I have termed the Older Palaeozoic Limestones and mapped in the lower portion of the valley hereabouts. This brecciated limestone, very similar in appearance to the typical Plateau Limestone of the Federated Shan States, is indeed the characteristic feature of Prof. Gregory's Minchia series, but with it he associated various shales, sandstones and grits and some occurrences of porphyries, coarse porphyritic basalts and diabase. The whole assemblage covers an extensive area in north-western Yunnan; the only fossil from it whose identification is reliable is that by Dr. Cowper Reed of an Upper Devonian *Uncinulus*.

Whatever interpretation is placed on Prof. Gregory's results however, the fact remains that he, as well as von Loczy, Credner and myself, regarded the complex on the eastern side of the Salween valley as of Palaeozoic age. The proof of the occurrence of fossiliferous Mesozoic strata amongst them. which we owe to Dr. Cowper Reed, has far reaching consequences; we may accept the Indian view that the Liu-wun fauna is to be ascribed to the Kimmeridgian, (Upper Jurassic), or, on the other hand, we may agree with the French suggestion that it should be placed in the Norian, (Upper Triassic), but in either case, theories based on the assumption that the Yunnanese highlands have remained above sea-level since Palaeozoic times, must be modified.

Before discussing the Brachiopod Beds themselves there are two closely connected subjects which it is opportune to mention here. The first concerns the age of the volcanic rocks and the second the cause of the disturbance which has disarranged the whole sequence.

Age of the volcanic series of the Salween Valley.

Mr. T. K. Huang has made the interesting suggestion that the basic rocks of the great river valleys of western Yunnan, are 'nothing but the Omeishan Basalt[2]'. This is the name given to a series of basaltic lavas and tuffs which has a wide extension in the Chinese provinces of Szechuan, Yunnan and Kueichow. Its volcanic origin is proved by its definite geological position, by its association with tuffs and by its vesicular structure. Its position

[1] *Ibid.*, p. 236.
[2] *Mem. Geol. Surv. China*, Ser. A, No. 10, p. 70, (1932).

in the Permian rocks of China has been accurately fixed, since it is always found above the Maokou Limestone and below the Luipakou or Choutang series. In official publications of the Geological Survey of China these are correlated with the Lower and Middle Productus Limestones of the Salt Range, respectively. Further, in those parts of central and western Yunnan where the Luipakou series is missing, and the basalt is followed by the Red Beds of Triassic age, Mr. Huang thinks it is possible that the Luipakou series was actually replaced by basaltic lavas. While these welcome ideas may be correct as far as they go and within certain definite limits in the Yangtze, Mekong and Salween valleys, elsewhere there is evidence of volcanic rocks both older and younger than those of the Salween suite. It is indeed possible that we have to deal with a series of far greater extension in time than this, comparable more, for example, with the Panjal traps of Kashmir, ranging as they do from the Upper Carboniferous to the Middle Trias.

Cause of the Salween disturbance.

Although little is known of the intimate structure of the Salween section with which we are concerned, there is a foundation for the suspicion that its disturbed, and probably in parts inverted, state, is a result of regional movements of great magnitude which, though only appreciable in sketchy outline at present, seem to indicate the play of unusually powerful orogenic forces operating from a westerly direction.

For example, from the next valley to the east, that of the Mekong, about latitude 24°, I have described another complicated succession.[1] This, according to M. J. Hoffet, is identical with the section in the same river valley much further to the south and in the extreme north-western corner of French Indo-China, where the Mekong forms the boundary between that territory and the Southern Shan States, and, further, is to be interpreted in exactly the same way. Briefly, this is that the Upper Laos are overthrust from the direction of Burma, in an arc convex towards the east, following the course of the Upper Mekong and nearly parallel to the better-known arc which limits the over-riding of the Upper Laosian element on that of western Tongking.[2] M. Hoffet believes that both examples from the Mekong valley are parts of the same overthrust, and if

[1] *Rec. Geol. Surv. Ind.*, LIV, pp. 305-308, (1922).
[2] *C. R. Ac. Sc.*, Tome 199, pp. 680-682, (1934).

such should prove to be the case, this major tectonic feature is traceable for at least 250 miles.

The crumpled Palaeozoic and Mesozoic rocks of western Yunnan are wedged in and straitened between two great pre-Palaeozoic *massifs*, that of the Burma--China border on the west, stretching from the Ruby Mines through Bhamo, Myitkyina and Putao into the little-known ranges beyond eastern Assam, and that of the Yalung valley, the southerly flowing tributary of the Yangtze, and western Szechuan, on the east, and there is no longer any doubt regarding the main direction of the forces to which they have been subjected. Professor Gregory has reviewed the evidence which leads to his conclusion that the Indo-Malayan Hercynian movements have contributed to western Yunnan its predominant structure, through this was complicated later by the younger Himalayan movements, influenced of course by the results left by their predecessors. Overfolding and thrusting due to pressure acting from west to east, are, as Gregory pointed out, common in this region. One example from many quoted by him may be mentioned: the peaks which dominate both sides of the Si La pass (14,000 feet), between the Salween and the Mekong about Latitude 28°, are intensely overfolded by pressure from the west, a movement which is thought to be of comparatively modern geological date.[1] Of the five age groups into which he classified the Yunnanese faults, one set is confined to overthrusts and tilting during the compression of the region by the Himalayan movements. At the same time he inferred faulting of a more normal type in that portion of the Salween valley now under description, but it is doubtful to my mind if this alone is sufficient to account for the stratigraphical confusion which exists there. In my diary the probability of overthrusting on a large scale was mentioned, but the point escaped reference in my earlier published reports.

As distinct from Professor Gregory, the official geologists of French Indo-China attribute a Neotriassic age to the Mekong overthrust, as indeed they do to all the major movements which have affected the northern parts of their country, and it will be evident that the determination of the exact age of the Liu-wun Brachiopod Beds, the youngest marine fossiliferous rocks known to be involved, has an important bearing on this controversial question.

[1] *Phil. Trans.*, Ser. B., Vol. 213, pp. 200, 232-240, (1925).

II.—THE BRACHIOPOD BEDS.

From a dark greenish-grey, rather soft and earthy limestone or calcareous shale which crops out two miles below Liu-wun, about Lat. 25° 4′ and Long. 99°, I collected many hundreds of specimens of *Rhynchonella*, a few of *Terebratula* and a very few poor and imperfect lamellibranchs, mostly in a fragmentary condition. At the time and in the field I wrongly attributed the *Terebratula* to the closely related genus *Dielasma*, and as such it appears in my earlier brief notice of these rocks.[1] The brachiopods occurred mainly in one small area and were lying on the surface, completely weathered out from their matrix, which is crowded with forms of the same kinds. It is the calcareous shale numbered 9, in the notice just mentioned, but as A. W. Grabau has pointed out, beds numbered 7 and 8, which consist of more massive limestones, probably belong to the same group.[2] Detached blocks of rock undoubtedly derived from them contained many broken specimens of *Rhynchonella* of much the same appearance. In the following list the fossils which have been identified by Dr. Cowper Reed from my collections are tabulated.[3]

BRACHIOPODA.

Rhynchonella (*Burmirhynchia*) *praestans*, Reed.
,, (,,) ,, var. *conjurata*.
,, (,,) var. *adjudicata*.
,, (,,) ,, var. *tenuiplicata*.
,, (,,) var. *luchiangensis*.
,, (,,) var. *discreta*.
,, (*Cryptorhynchia* ?) sp.
,, (Subgenus ?) aff. *cuneiformis*, Mansuy.
Terebratula (*Holcothyris*) *ancile*, Reed.
,, (,,) cf. *flexa*, Buckm.
,, (,,) *pinguis*, Buckm. var. *luchiangensis*.
,, (,,) ,, var. *olivaeformis*.
,, (,,) ,, var. *longisulcata*.
,, (,,) cf. *subovalis*, Buckm.
,, (*Loboidothyris*) cf. *perovalis*, Sow.

[1] *Rec. Geol. Surv. Ind.*, XLVII, p. 233, (1916).
[2] Stratigraphy of China, Pt. I, p. 232, (1925).
[3] *Pal. Ind.*, N. S., Vol. X, Mem. No. 1, pp. 254-274, (1927).

PELECYPODA.

Exogyra bruntrutana, Thurm.
„ cf. *dubiensis*, Contej.
„ *eminens*, Reed.
Pecten (*Camptonectes*) *lens*, Sow.
„ (*Syncyclonema*) *luchiangensis*, Reed.
Lima (*Radula*) aff. *monsbeliardensis*, Contej.
„ ? sp.
Modiola sp.
Cucullaea cucullata, Goldf.
„ aff. *virgata*, Sow.
Arca aff. *thurmanni*, Contej.
Nucula aff. *menkei*, Roem.

Owing to the abundance of intermediate and transitional forms amongst the specimens of *Rhynchonella*, Dr. Cowper Reed found it exceedingly difficult to refer these Yunnanese examples to any of the numerous species created by S. S. Buckman for the members of this genus from the Namyau beds of the Northern Shan States, and at the same time to observe his precise definitions. The affinities of some of the forms are often with not one but several of Buckman's species, but to which particular one the resemblance is closest it often proved impossible to decide. Dr. Cowper Reed explains therefore that some of his new specific names are employed with a greater latitude of variation in each species than Buckman strictly permits.

The similarity of this brachiopod fauna with that of the Namyau beds is remarkable, for although the great majority of the specimens are referred to the new species *Rhynchonella* (*Burmirhynchia*) *praestans*, Reed, or its five varieties, Dr. Cowper Reed states that the species itself is closely similar to *Burmirhynchia costata*, Buckm., a typical Namyau form. The ornamentation is almost identical, and although the anterior union of the valves seems to be different, the shape of the muscle-scar in the brachial valve is the same in both species. Another important point is the external resemblance between *Rhynchonella praestans*, Reed, and *Rhynchonella mahei*, Mansuy, from the Laos, though, as will be shown later, the beds in which the latter species occurs are no longer supposed to be of Liassic age. The occurrence of *Rhynchonella* (? subgenus) aff. *cuneiformis*, Mansuy, is another link with Indo-Chinese forms,

but in this case again, the Callovian horizon to which it is attributed in Tongking is no longer valid. This remark also applies in other later instances where the Callovian of Indo-China is mentioned.

Of the five species of *Terebratula*, one, *Terebratula* (*Holcothyris*) *ancile*, Reed, is new, but it is stated to be closely allied to *Holcothyris angusta*, Buckm., from the Namyau beds and to be somewhat like *Holcothyris laosensis*, Mansuy, from the Callovian of the Laos. The two species *H.* cf. *flexa*, Buckm., and *H.* cf. *subovalis*, Buckm., possess characters which are typical of the Namyau shells with which they are compared. The species which Buckman described as *Holcothyris pinguis*, from the Namyau beds, is present in three forms which are distinguished by new varietal names. The remaining example, *Terebratula* (*Loboidithyris* ?) cf. *perovalis*, Sow., is stated to resemble somewhat *Zeilleria intermedia*, Mansuy, from the Callovian of the Laos.

Buckman ascribed a Middle Jurassic (Bathonian) age to the Namyau limestones; if this is correct and if the brachiopod fauna of the Liu-wun beds was the only available standard of comparison, a similar age would have to be given to them. The results of the examination of the lamellibranchs, however, have led Dr. Cowper Reed to a different conclusion, which is best stated in his own words as follows :—

'The similarity of the brachiopod fauna of these Liu-wun beds with that of the Namyau beds of Burma is striking, but in the case of the other fossils the evidence does not point to the same age as Buckman deduced from the brachiopods, for they have Oxfordian or Kimeridgian affinities and some of the species are almost indistinguishable from common European Upper Jurassic forms. Probably they come from a higher horizon than the Oxfordian series, for some of the fossils are closely related to or identical with forms which occur in the Sequanian or Kimeridgian. Unfortunately no ammonites are present in the material available. On the whole a Kimeridgian age may be ascribed to this fauna.'[1]

Thus the anomalous position is reached that while the brachiopods point to horizons well down in the Middle Jurassic as suitable for the reception of the Liu-wun beds, the lamellibranchs indicate that they should be placed in the lowest subdivision of the Upper Jurassic.

About twenty miles to the south of the traverse already described, I crossed the Salween valley again by the track which leads from

[1] *Pal. Ind.*, N. S., Vol. X, Mem. No. 1, p. 255, (1927).

Another occurrence of the Liu-wun beds.

Lungling T'ing to Shun-ning Fu. Here, once more, though the Irrawaddy-Salween divide is somewhat lower and broader, it is built of the same crystalline rocks and intrusive granites, overlain on the east by the phyllites and associated members of the Kaoliang series. followed in their turn by metamorphosed limestones and limestone breccias as before. The river itself flows between steep limestone cliffs rising from the water for some hundreds of feet, and ascending from the eastern bank is a complex similar to that of the more northerly traverse, limestones and shales, marly and sandy beds, intercalated with tuffs and flows of basic rocks. The succession. or at any rate that portion of it which can be determined in the course of a single rapid march, has already been given.[1] Much of it is doubtless of Permo-Carboniferous or Permian age, but at the bottom of the last ascent to Tai-ping-tzu, a small village lying at an elevation of 4,000 feet, two miles from the ferry across the Salween, I collected specimens of shelly limestone which were examined by Dr. Cowper Reed. He found that the rock is composed almost entirely of a mass of small oysters with a few fragments of a large species of *Pecten* and two or three very imperfect doubtful brachiopods. Although these fossils do not indicate its age precisely, so far as their affinities are determinable, they suggest an Upper Jurassic horizon and possibly the same as that at Liu-wun, further north. This possibility is strengthened by the fact that both occurrences possess more or less the same strike. Shelly limestone bands of the kind described occur elsewhere in the same vicinity, for instance about four miles further to the north-east, and just below Teng-tzu-p'u there are examples which are full of the fragmental remains of innumerable bivalves and other fossils.

Possible occurrence of Mesozoic rocks near Pu-piao.

Returning again to the northern traverse, at the western edge of the Pu-piao plain and two miles from the village of the same name, there are outcrops of compact light grey limestone which have previously been regarded as Permo-Carboniferous. On a piece of this material Dr. Cowper Reed recognised a weathered irregular calyx of a coral resembling *Thecosmilia*, apparently undergoing fission, so that it has the irregular transverse shape of such species as *Th. clathrata*, Emmr., *Th. De Filippi*, Stopp. and other Triassic species. The septa, so far as they are preserved,

[1] *Rec. Geol. Surv. Ind.*, XLVII, pp. 253-256, (1916).

seem also to show the characters of this genus.[1] The specimen seems to indicate a Mesozoic age for this particular limestone, though its stratigraphical relation to the Liu-wun beds is quite obscure.

Triassic limestones of the Salween valley, west of Taipingtzu.

From about two miles below Lameng and shortly before the ferry across the Salween is reached, on the more southerly of the two routes by which I crossed its valley, I have described occurrences of laminated, light grey limestones and of platy, dark greyish-blue bands with impressions of bivalves, which at the time I thought belonged to some Carboniferous horizon[2]. These lamellibranchs have unfortunately proved to be indeterminable, but Dr. Cowper Reed considers that the concentric ridges and striae of some of them indicate shells which might belong to *Carbonicola, Edmondia* or *Allorisma* [3]. He also draws attention to certain resemblances between these specimens and the Upper Permian lamellibranchs from Fukien figured by Grabau as *Carbonicola* and *Anthracomya*[4].

An imperfectly preserved coral from the grey limestone has been determined by Dr. Cowper Reed as *Thecosmilia* aff. *weberi*, Vin. de Regny, a form from the Trias of Timor. It is also allied to *Thecosmilia clathrata*, Emmr[5]. These limestones thus belong to some undetermined horizon of the Trias.

It must be more than coincidence that limestones with Triassic corals have been found in both sections of the Salween valley which were traversed, in one case to the west and in the other to the east of the brachiopod-bearing limestones. It leads to the supposition that some at least of the contemporaneous igneous rocks amongst which they occur are of the same age.

III.—COMPARISON WITH THE NAMYAU LIMESTONES OF THE SHAN STATES.

The main area in the Northern Shan States occupied by rocks of the Namyau series, as mapped by T. D. La Touche, stretches from a point 20 miles south-south-west of Hsipaw in a north-easterly direction for over 50 miles to positions north of latitude 23°, gradually increasing in width at the same time to a maximum of 16 miles. There are outlying patches of what was once a wider spread

[1] *Pal. Ind.*, N. S., Vol. X, Mem. No. 1, p. 279, (1927).
[2] *Rec. Geol. Surv. Ind.*, XLVII, pp. 253-254, (1916).
[3] *Pal. Ind.*, N. S., Vol. X, Mem. No. 1, pp. 277-278, (1927).
[4] Stratigraphy of China, Pt. I, p. 485, (1925).
[5] *Pal. Ind.*, N. S., Vol. X, Mem. No. 1, p. 251, (1927).

covering, further east, especially near Lashio. Except in the south, the inner or western boundary of the main area follows the general trend of the margin of the pre-Palaeozoic rocks remarkably closely, though the Namyau series is separated from them by a narrow strip of Plateau Limestone followed in its turn by the zone of the Silurian and Ordovician beds. Between the southern termination of the Namyau band and the older Palaeozoic zone lies a patch of the Napeng beds, containing the type-localities of these, the only other fossiliferous Mesozoic rocks of the Northern Shan States.

Beyond latitude 23°, the extension of the Namyau Series was surveyed by myself for a brief period in 1916, by G. V. Hobson in 1929 and more systematically by Dr. M. R. Sahni between 1930 and 1933, resulting in the mapping of the main area for another 65 miles to the north-east. I am indebted to Dr. A. M. Heron, Director of the Geological Survey of India, for a copy of the new geological map, as far as it has been completed north of latitude 23°, and from it and the earlier one, I have prepared the small scale sketch map reproduced as Plate 26. It again emphasizes the general parallelism between the trends of the pre-Palaeozoic rocks and the Namyau series, though with an unusual overlap of the latter on to the former in one position; the existence of a long new strip of Napeng beds, in its normal position between the Namyau series and the older Palaeozoic zone and, finally, the splitting of the main Namyau band by an inlier of ancient Chaung Magyi rocks at the eastern margin of the mapped area. In the neighbourhood of Nam Tu, where the boundary of the pre-Palaeozoic rocks assumes for a short distance an unusual direction of a little to the west of north, the inner limiting line of the Namyau series follows the same course, only to swing round to the north-east again, copying the outer margin of the ancient rocks of the Khodaung Hill Tracts and of the Shweli valley about Namkham. Across the Chinese frontier in Yunnan, the pre-Palaeozoic trend becomes north and south and the occurrence of the equivalents of some part of the Namyau series in the Salween valley there might well have been predicted from their known location and consistent behaviour on the British side of the border, had these been known at a earlier date.

The Brachiopod beds of Liu-wun correspond only to one or more of the thin but persistent limestone bands found towards the base of the Namyau series, at any rate north of latitude 23°, which,

apart from their faunas, are of little significance in the great mass of red sandstones and shales, with beds of grey and speckled sandstones and layers of yellow clay, totalling, according to T. D. La Touche, many thousands of feet in thickness[1]. Other features bearing on our comparison may be briefly mentioned. Discontinuous bands of coarse conglomerate sometimes occur at the bottom of the series, but in the only instance known to La Touche where the Namyau series is associated with the underlying Napeng beds, the section is so obscure that their exact relations could not be ascertained[2]. Finally, La Touche believes that the limestones of the Namyau series have been profoundly disturbed, for they generally dip at high angles and are often vertical[3].

Age of the Namyau brachiopods.

About a thousand specimens of brachiopods collected from the Namyau limestones by T. H. D. La Touche, P. N. Dutta and G. E. Pilgrim, were examined and described by the late S. S. Buckman, who found that they consisted entirely of members of the two great families the *Rhynchonellidæ* and the *Terebratulidæ*. He separated the former into two new genera :—*Burmirhynchia*, with forty new species and *Sphenorhynchia* (?), with two new species, while all the latter were placed in one new genus :—*Holcothyris*, with twenty-two new species. In this considerable collection of brachiopoda, Buckman concluded that there seemed to be no identity with any known forms and the evidence for the correlation of the Namyau limestones with European or other strata proved particularly scanty[4]. In the complete absence of specific identity and with very little generic identity between the Namyau brachiopods and those from other localities, Buckman was compelled to consider general resemblances in his attempted correlation with European strata, but to what extent these are to be regarded as infallible guides is merely a matter of opinion. In the case of the terebratulids, he found a remarkable resemblance to a new series of Bathian forms, *Avonothyris* ; but this was further described as only a general resemblance, not identity, and the species could not be regarded even as congeneric. As to the rhynchonellids, he noted a general resemblance to the European species of the Bathian, say from Great Oolite to Cornbrash, but generic resemblance only existed in a

[1] *Mem. Geol. Surv. Ind.*, XXXIX, Pt. 2, p. 304, (1913).
[2] *Ibid.*, p. 286.
[3] *Ibid.*, p. 304.
[4] *Pal. Ind.*, N. S., Vol. III, Mem. No. 2, p. 216, (1917).

few cases to certain rhynchonellids of the Great Oolite (Bathian) of England and France, more or less related to *B. hopkinsi*, Davidson, but mainly new species. Buckman ends his argument by direct comparison as follows:—

'The geological position, therefore, which is indicated by the generic affinities of the rhynchonellids is fairly confirmatory of that suggested by a more general likeness of the Terebratulids; it points to Bathian near about the Bradford Clay. In such case some correspondence with the Brachiopod fauna from the Putchum Beds of Cutch might be expected; but that can hardly be claimed; there is less than with the Bathian of Europe. There are no species of *Burmirhynchia*, nor of *Holcothyris* in the Putchum Beds as illustrated in Dr. Kitchin's memoir; but there are species of *Burmirhynchia* in the Bathian of Europe.'

He then proceeds to arrive at the same result by indirect methods of morphogenetic comparison, involving many suppositions, which though they may not be impossible, admittedly make too strong a demand on probability and as such need not be considered here[1].

An important contribution to the study of the Namyau limestones and their relations with the Liu-wun brachiopod beds, was made by Dr. Cowper Reed, who visited the Northern Shan States in 1927[2]. At the Ta-ti locality in Hsipaw State, already known from La Touche's work and Buckman's descriptions of its brachiopods, he found shelly limestones, crowded in places with small crushed shells of species of *Exogyra* and *Ostrea*, amongst which brachiopods also occur. At a new locality, near mile-post 18-4 on the road from Lashio to Nam Tu, the limestone bands, dipping east at about 45°, are full of the same assemblage of brachiopods and small broken oysters. The following lists tabulate the species which have been recognised, while those which also occur at Liu-wun are marked =.

Dr. Cowper Reed's investigations in the Northern Shan States.

Locality 1. —Ta-ti, Hsipaw State.

= *Terebratula* (*Holcothyris*) *pinguis*, Buckm.
,, (,,) *subovalis*, Buckm.
,, (,,) *rostrata*, Buckm.
= *Exogyra eminens*, Reed.
,, cf. *multiformis*, Koch and Dunk.
,, cf. *monsbeliardensis*, Contej.
= *Pecten* (*Syncyclonema*) *luchiangensis*, Reed.
= ,, (*Camptonectes*) *lens*, Sow.

[1] *Pal. Ind.*, N. S., Vol. III, Mem. No. 2, pp. 216-219, (1917).
[2] *Rec. Geol. Surv. Ind.*, LXV, pp. 185-187, (1931).

With these are found in addition the following six of Buckman's forty species of *Rhynchonella* (*Burmirhynchia*)—*shanensis*, *inequalis*, *namyauensis*, *lenglawngensis*, *ovalis* and *globulus*.

Locality 2.—Near Mile 18-4, Lashio-Nam Tu Road.

Terebratula (*Holcothyris*) *angusta*, Buckm.
,, (,,) *delta*, Buckm.
,, (,,) *expansa*, Buckm.
= ,, (,,) *pinguis*, Buckm.
= ,, (,,) *subovalis*, Buckm.
= *Exogyra bruntrutana*, Thurm.
,, *multiformis*, Koch and Dunk.
,, cf. *virgula*, Sow.
Alectryonia rastellaris, Münst. (=*gregaria*, Sow.).
Lima sp.
Cerithium sp.

With these also occur the following amongst Buckman's species of *Rhynchonella* (*Burmirhynchia*):—*asiatica*, *dattai*, *globulus*, *irregularis*, *nammaensis*, *namtuensis*, *orientalis*, *pilgrimi*, *pinguis*, *pyriformis*, *seengensis* and *subtrigonalis*.

In lithological and palæontological characters as well as in facies these shelly limestones are closely similar if not identical with those of Liu-wun. Dr. Cowper Reed writes that—

'Several of the species are identical and others closely allied, and we may with considerable assurance correlate the beds in these three localities and regard them as belonging to the same stratigraphical horizon. There does not seem any sufficient reason to revise the previous conclusion that the position of these beds is in the Upper rather than in the Middle Jurassic, though possibly they are Oxfordian rather than Kimmeridgian.'

As Dr. Cowper Reed points out amongst the ammonites, mollusca and brachiopods from the coastlands of Kenya, described by L. F. Spath and J. Weir, there are several species of the latter two groups that are apparently identical with those from Burma and Yunnan. This is also the case with the fossils from Jubaland and Somaliland with which the Kenya fauna also has close affinities. The age of the latter is considered to be Argovian-Kimmeridgian.

The only other information available on the Namyau series and related Mesozoic beds in the Northern Shan States, consists of the all too brief notices which have appeared from time to time in the annual reports of the Directors of the Geological Survey

of India, as the mapping of the north-eastern corner of the region, north of latitude 23°, has proceeded.

Mr. G. V. Hobson's Passage beds of possible Norian age.

Mr. G. V. Hobson found in the south-eastern portion of Sheet 93 E/7 and in the north-western part of its neighbour on the east (93 E/11), that the Plateau Limestone is for the most part covered with younger sediments which he regarded as mainly of Rhaetic age, though on what evidence is not stated in the only short summary of his work which has been published. As the covering of the limestone hereabouts is more complete than appears to be the case further south, he suggested that the marine transgression responsible for its formation came from the north-east, that is from Yunnan. Of unusual interest is the occurrence of a series of unfossiliferous dark grey, thin-bedded limestones with intercalated sandstones, passing up into carbonaceous sandstones, between the Plateau Limestone and the Rhaetic beds, which Mr. Hobson tentatively termed "Passage beds" of possible Norian age. Argillaceous limestone containing typical Namyau brachiopods was found at one locality only[1].

Dr. M. R. Sahni's surveys.

Continuing Mr. Hobson's work to the north-east on to Sheet 93 E/11, Dr. M. R. Sahni found a series of very fossiliferous, yellow or purple clays, grey shales, dark blue compact limestones and grey argillaceous limestones, near the Shan village of Na Keng. He is of the opinion that while the fauna of these beds indicates affinities with that of the Napeng beds through such forms as *Palaeoneilo nanimensis*, *Dentilucina mona*, *Promathilda exilis* and *Pecten (Aequipecten) bayzandi*, which were all new species originally described by Miss M. Healey, it is, on the whole, distinct from it. The total absence of the *Burmesiidae* and of the Rhaetic zone fossil *Pteria (Avicula) contorta*, Portlock, is very significant and, it is added, the majority of the forms found at Na Keng belong to species that have not so far been described. Amongst the lamellibranchs there is said to be a new species belonging to each of the following genera—*Pecten*, *Modiola*, *Cardium* and *Protocardium*, while a single specimen of *Posidonomya* was also collected. The last-named genus is new to the Napeng beds. Of[2] the gastropods a new species of

[1] *Rec. Geol. Surv. Ind.*, LXIII, p. 92, (1930).
[2] *Ibid.*, LXV, p. 87, (1931).

Pleurotomaria occurs very profusely in a dark grey argillaceous limestone.

Outliers of the Namyau series were found in a number of localities, consisting of the usual purple sandstones, clays, speckled sandstones and interstratified beds of grey argillaceous limestone. the whole being folded in an approximately north-east and south-west direction. From the limestones, which have yielded a rich brachiopod and molluscan fauna, the following species were determined :--

Cererithyris ovalis, Buckm.
,, sp. nov.
Burmirhynchia depressa, Buckm.
= ,, *irregularis*, Buckm.
,, *transversalis*, Buckm.
,, *regularis*, Buckm.
= ,, *pinguis*, Buckm.
= *Syncyclonema luchiangensis*, Reed.

together with new species of *Pecten*, *Modiola* and *Patella*.

The rhynchonellids marked=occur in Dr. Cowper Reed's collection from "mile-post 19-4", on the Lashio-Nam Tu road, while the lamellibranch, *Syncyclonema luchiangensis*, Reed, has been found at Liu-wun. Although attention is not drawn to it in the Annual Report in question, Dr. Sahni's determination of *Cererithyris ovalis*, Buckm., is of great interest, as the genus as not been found in the Namyau series before, and this particular species was created by Buckman for a fossil from the English Cornbrash. Thus, this is the first and as yet single instance of definite specific identity between a brachiopod of the Namyau limestones and a European form. The rhynchonellids collected at Loi Lem, a locality which yielded no terebratulids, indicate, in Dr. Sahni's view, an age near the Bradfordian, but the terebratulids from Hsai Hkao seem to point to the Cornbrash and it is suggested that separate horizons may be represented at the two places[1].

In the years 1931 to 1933, Dr. Sahni continued his mapping across Sheets 93 E/10, 11, 13, 14 and 15, up to longitude 98°, and proved the continuity of the main band of the Namyau rocks striking to the north-east the whole way; brief outlines of his progress have been published in the General Reports. He refers

[1] *Ibid.*, pp. 87, 88.

to the Namyau rocks in these regions as fine to coarse-grained purple sandstones with occasional beds of grey shale and interstratified bands of argillaceous limestone. Thus their dominant lithological characters further south still persist. Dips are generally high. With the exception of a few indeterminable fragments of lamellibranchs, the sandstones are unfossiliferous. A few fossils occasionally occur in the shales, but the limestones are nearly always fossil-bearing and have yielded a prolific fauna. Amongst others the genera *Holcothyris*, *Burmirhynchia*, *Alectryonia*, *Cardium*, *Protocardium*, etc., are mentioned. Amongst many new localities those of Kongnim (23° 45′ : 97° 55′ 30″) and Kawng-hka (23° 50′ 30″ : 97° 59′), are outstanding in the variety of their lamellibranch remains. At Kawng-hka they exist alone: at Kongnim they are associated with the brachiopods *Burmirhynchia* and *Holcothyris*. The lamellibranchs belong to the genera *Leda*, *Nucula*, *Mytilus*, *Crassatellites*, *Astarte*, *Thracia*, *Pecten*, *Ostrea* and *Lima*. The Brachiopoda so far identified include the following:—

‡ *Burmirhynchia namtuensis*, Buckm.
‡ „ *irregularis*, Buckm.
„ *senilis*, Buckm.
= „ *shanensis*, Buckm.
„ *hpalaiensis*, Buckm.
= „ *namyauensis*, Buckm.
„ *depressa*, Buckm.
|| ‡ = *Holcothyris pinguis*, Buckm.
‡ „ *expansa*, Buckm.
„ *angulata*, Buckm.

Of this list, one species marked ||, occurs at Liu-wun, three marked = at Dr. Cowper Reed's Ta-ti locality and four marked ‡ at his "mile-post 18-4", Lashio-Nam Tu road[1].

The ammonite beds of Na Hkyam, North Shan States.

The probable existence of older Triassic limestones in association with the two known occurrences of the Liu-wun brachiopod beds in Yunnan has a parallel in the Northern Shan States, where a series of argillaceous limestones and shales containing a rich fauna of ammonites and gastropods was discovered by Dr. Sahni at Na Hkyam (97° 45′ : 23° 17′) in 1931.[2] They are stated to be inter-

[1] *Rec. Geol. Surv. Ind.*, LXVI, p. 97, (1932); *op. cit.*, LXVII, p. 46, (1933); *op. cit.*, LXVIII, pp. 21, 58, (1934).

[2] *Op. cit.*, LXVI, pp. 97, 98, (1932).

stratified amongst dolomites but as the nearest exposures of the Namyau rocks lie only about half a mile away, I prefer to associate them provisionally rather with the Mesozoic rocks than with the Plateau Limestone, in the usually accepted meaning of the term. According to Dr. Sahni's preliminary determinations the ammonites include *Xenaspis carbonaria*, Waagen, *Nannites* cf. *hindostanus*, Diener, and *herberti* Diener, *Nannites*, sp., but the commonest form belongs to a new genus of the *Hungaritidæ*. Amongst the gastropods the dominant genera are *Pleurotomaria* and *Naticopsis* (four species), while others are referred to *Murchisonia*, *Neritomopsis*, *Trochus*, and *Platyceras*... A single species of *Holopella* is said to be very similar to *Holopella trimorpha*, Waagen. Numerous lamellibranchs were also collected, including forms of *Schizodus*, *Pecten* and *Aviculopecten*, of which the first named is the commonest.

Xenaspis carbonaria is an important leading fossil of Permian age in the Productus Limestone of the Salt Range, in the Kuling shales of Spiti, in the exotic block of Chitichun No. 1, and in the highest horizon of the Zewan beds of Kashmir[1]. *Nannites* is a Triassic genus exclusively and the species *N. hindostanus* is known to persist through all the stages of the Himalayan Lower Trias, while *N. herberti* occurs in the Otoceras beds of Spiti, of Lower Triassic age and correlated by Diener with the unfossiliferous clays and shales lying between the Upper Productus limestone and the Lower Ceratite limestone of the Salt Range.[2] *Holopella trimorpha* is an Upper Productus limestone fossil.[3] Until the collections are systematically described it is impossible to fix either their age or relationship, though it appears that they may belong to either the uppermost Permian or the lowermost Trias. Some 20 miles further west lie Mr. Hobson's pre-Napeng passage beds, so that in this region there is available for future study the most complete sequence of Shan Mesozoic formations yet discovered. Contacts of the Napeng beds and the Namyau series have also been mapped hereabouts and if the stratigraphical bearings between these two groups on the one hand, and between the Na Hkyam beds and the Namyau series on the other, have not been clearly determined by recent field work, it is an area where more detailed investigation

[1] *Pal. Ind.*, N. S., Vol. V, Mem. No. 2, p. 110, (1915).
[2] *Op. cit.*, Vol. VI, Mem. No. 1, pp. 142, 179, (1909).
[3] *Op. cit.*, Ser. XIII, Vol. I, Pt. 2, p. 94, (1880).

should soon lead to results which would settle the contentious questions of the proper correlation of these rocks.

IV.—COMPARISONS WITH INDO-CHINA.

The Mesozoic rocks of Yunnan and of the Federated Shan States are found again in the adjoining regions of Indo-China, to the south and south-east respectively, and I shall try to summarize here as concisely as possible the reports of the official French geologists on the various formations which may be the equivalents of the Liu-wun beds; themselves, as we have seen already, to be correlated with at least part of the limestones of the Namyau series of the Northern Shan States.

The brachiopod limestones of Luang Prabang.

In 1896, three years before Messrs. T. H. D. La Touche and P. N. Dutta commenced the survey of the Northern States, H. Counillon drew attention to the occurrence of limestones with a rich fauna of brachiopods, near Luang Prabang, on the Mekong and in the Laos. It is unnecessary to trace the various descriptions of these rocks and their fossils through the lengthy literature which has grown around them and to which many of the distinguished geologists of the *Service géologique de L'Indo-Chine* have contributed, including, besides H. Counillon, G. Monod, H. Mansuy, Capt. Zeil, C. Jacob, Commandant Dussault, Capt. Patte and J. Fromaget. It must suffice to state that the limestones occur in the central part of the Quan Houng syncline, the flanks of which are formed of red sandstones underlying red clay shales and conglomerates, a group of rocks which is known as the "Grès et Argiles rouges du Haut Laos." The limestones themselves are very laminated and full of earthy matter. Up to the time of their examination by Messrs. Jacob and Dussault in 1925, they were believed to be of Liassic age on the strength of the occurrence of the following fossils in them, the determinations of which were made by H. Mansuy.[1]

Pentacrinus sp.
Spiriferina acuta, Mansuy.
Hustedia orientalis, Mansuy.
Rhynchonella pseudopleurodon, Mansuy.
Rhynchonella mahei, Mansuy.
Terebratula brevirostris, Mansuy.

[1] *Bull. Serv. Géol. Indochine*, Vol. XIII, Fasc. IV, pp. 6, 7, 52-54, (1924).

Jacob and Dussault, however, found a single small ammonite in them which Capt. Patte determined as *Discophyllites laubei*, Gemm., a form which occurs in the Upper Trias of Sicily. It then seemed that the Brachiopod limestones of Luang Prabang would have to be removed from the Lias into the Upper Trias and this opinion was abundantly confirmed by M. J. Fromaget's work. He visited the locality at the end of 1928, and in addition to further specimens of *Discophyllites*, collected others belonging to the genera *Tibetites* and *Arcestes* as well as a *Nautilus* allied to *Clydonautilus griesbachi*, Mojs., one of the zone fossils of the lower part of the Himalayan Norian.[1] *Tibetites* and its subgenera occur in the same stage while *Arcestes* is found both in the Carnian and Norian of the Himalayas as well as the Anthracolithic of the Salt Range.

On palæontological grounds then the Norian age of these Luang Prabang limestones must be regarded as reasonable and Fromaget attributes no importance to the brachiopods which make up the bulk of the fauna, in spite of the fact that certain rhynchonellids are admitted to be identical, or to present very close affinities with examples from the Namyau and Liu-wun limestones (*see* page 202). On the other hand *Spiriferina acuta*, Mansuy, is comparable with *S. shalshalensis*, Bittn., of the Himalayan Carnian and *Terebratula brevirostris*, Mansuy, greatly resembles T. *pyriformis*, Suess, of the Rhætic schists of Kœssen in the Carpathians.

The stratigraphical evidence leads to the same conclusion. The brachiopod-bearing limestones are now recognised as the terminal member of a great marine Triassic series, found along the whole length of the valley of the Nam Ou from the vicinity of Phong Saly and which finally disappears to the south-west of Luang Prabang by stretching and flattening under overthrust masses of the Anthracolithic, but which laterally, in other directions, passes into clays and sandstones of a sub-continental character. The limestones and the underlying beds in conformity with them are folded; above them, separated by a pronounced discordance, are practically horizontal red beds of the usual type forming part of the wide-spread, post-Triassic covering and generally referred to as 'Grès supérieurs' or 'Grès continentaux'.

In view of the close geographical association of the Namyau series and the Napeng beds in the Northern Shan States, it

[1] *Pal. Ind.*, Ser. XV, Vol. IV, Pt. 1, p. 136, (1890).

is essential to mention here that near Con Tagne, a locality which lies much nearer the Southern Shan States than Luang Prabang, and is probably not more than 60 miles in a straight line from the nearest point on the Burma-Indo-China frontier, Messrs. Jacob and Dussault found a series of clay shales, resting on limestones of Palæozoic appearance and containing a typical Napeng fauna. Of thirteen species identified by Capt. Patte from their collection, eight are typical Napeng forms, three are closely allied and two are new. Such typical Napeng fossils as *Myophoria napengensis*, Healey, and *Pecten* (*Syncyclonema*) *quotidianus*, Healey, are very common, while *Burmesia lirata*, Healey, and an *Avicula* related to the zone fossil, *A. contorta*, Portlock, also occur. These strata are met with in a shaley series forming part of an anticlinal assemblage in the middle of a great spread of typical Red beds. From the standpoint of official Indian geology they are indubitably of Rhaetic age but they are now classified as Upper Trias in Indo-China.[1]

The Napeng beds of Con Tagne.

At the Signal Station of Phong Saly, the chief town of the Military Territory of the Upper Laos, a series of shales and sandy shales with abundant plant remains occurs below red shales and sandstones [2]. From the determinations of Mlle. Colani the shales are believed to correspond to the lower of the two well-known groups into which the Hongay flora of Tongking has been divided, that is to say, to the base of the Rhaetic. Now, although the plant remains which occur with the coal seams of Kalaw in the Southern Shan States are of Upper Lias to Lower Oolite in age, according to Dr. C. S. Fox, quoting Dr. G. de P. Cotter.[3] I hold the personal opinion that they will eventually prove to be more comparable with the Hongay flora, as indeed Dr. Cotter himself once thought possible.[4] Dr. B. Sahni's investigations of the six specimens of conifers from the Kalaw collection show that each of them may equally well be of Rhætic as of Jurassic age and the numerous ferns and cycads still remain to be re-examined.[5]

The plant beds of Phong Saly.

[1] *Bull. Serv. Géol. Indochine*, Vol. XIII, Fasc. IV, p. 43, (1924); *Mem. Serv. Géol. Indochine*, Vol. IX, Fasc. I, (1922).

[2] *Bull. Serv. Géol. Indochine*, Vol. XIII, Fasc. IV, p. 38, (1924).

[3] *Mem. Geol. Surv. Ind.*, LVIII, p. 166, (1931).

[4] *Rec. Geol. Surv. Ind.*, LV, p. 34, (1923); 'The Mineral Deposits of Burma', p. 6, (1924).

[5] *Pal. Ind.*, N. S., Vol. XI, pp. 99-101, (1931).

In explanation of this digression I wish to emphasize that the coal-bearing series of Hongay and other places in Eastern Tongking, the plant beds of Phong Saly, the Con Tagne beds with the Napeng fauna, and many other occurrences of the same kind in Indo-China, have been removed from the Rhaetic to the Norian, a position which in the opinion of M. Fromaget and other French geologists they share with the Napeng beds proper of the Shan States, the Namyau series and the brachiopod limestones of Yunnan. I reserve my views on the wider implications of these suggestions for a later paper dealing with the Trias of Yunnan, being concerned now only with the problem of the Liu-wun beds, the Namyau series and their more apparent equivalents. We may now consider the analogous brachiopod-bearing limestones of Pac Ma, Ban O and Hoang Mai.

The brachiopod limestone of Ban O, etc., Samneua Province, Laos.

Discovered by Commandant L. Dussault in 1920, the brachiopod limestones of Ban O and other places stretch from Ban O itself, some six miles north of Samneua, the capital of the province of the same name in the Laos, in a series of discontinuous outcrops for about 30 miles across tributary valleys of the Song Ma river. No higher beds are known in the region and the available information about their underlying strata is not very precise. In places they appear to rest on a series of sandstones and shales with beds of crushed rhyolite, but at others red sandstones and shales intervene. Their lower members are dark, calcareous shales and white, siliceous limestones followed upwards by purple and sometimes brecciated limestone. These beds, which are unfossiliferous, reach 640 feet in thickness and are overlain by 190 feet of hard, light grey, often oolitic and fossiliferous limestone, the Terebratula limestone proper. (Calcaires à Térébratules de Ban O).

For various reasons Commandant Dussault believes that the contact of these limestones with the underlying rocks in the exposures which he examined is not a normal one, but must be regarded as possessing a tectonic character and it is shown as such in his sections. At different localities these lower beds have yielded Virglorian ammonites and Middle Triassic fossils, elsewhere again, shales with the Carnian ammonite *Margarites samneuaensis*, Mansuy, apparently occur.[1]

[1] *Bull. Serv. Géol. Indochine*, Vol. IX, Fasc. II, pp. 54-56, (1920).

The following fossils, determined by H. Mansuy and considered by him to show Callovian affinities, have been obtained at Ban O :—

Holcothyris laosensis, Mansuy.
Aulacothyris dussaulti, Mansuy.
Zeilleria pentagona, Mansuy.
Zeilleria intermedia, Mansuy.
Pecten (?) *banoensis*, Mansuy.
Pecten sp.
Lima sp.
Neritopsidæ undetermined.

To this list J. Fromaget adds *Spiriferina* cf. *lipoldi*, Bittn. and *Aulacothyris inflata*, Mansuy. The reasons for his proposal to remove these limestones from the Callovian (middle Jurassic) to the Norian (Uppermost Trias) will be better appreciated after the Hoang Mai occurrence has been described below. From the palæontological point of view, however, it is pointed out that *Spiriferina* cf. *lipoldi* occurs in the Carnian of the Alps while *Aulacothyris inflata* presents remarkable affinities with *A. sandlingensis*, Bittn. of the Alpine Norian. A revision of the earlier fauna confirmed his view that the horizon is best attributed to the top of the Trias, for to him *Zeilleria intermedia*, Mansuy, appears identical with *Terebratula præpunctata*, Bittn., of the Dachstein (Norian); *Zeilleria pentagona*, Mansuy, seems inseparable from *Terebratula hungarica*, Bittn., from the Derno Beds (Upper Norian) while *Holcothyris laosensis*, Mansuy is stated to be only a variety of *Aulacothyris joharensis*, Bittn.[1] This species was described by Bittner from the well-known Bambanag section in the Girthi valley of the Kumaon Himalaya, where it occurs with *Spiriferina griesbachi*, Dien., of the Norian.[2] It remains to add that Dr. Cowper Reed found some resemblance between *Zeilleria intermedia*, Mansuy, and *Terebratula* cf. *perovalis*, Sow., from the Liu-wun Beds, and states further, that his new species *Terebratula* (*Holcothyris*) *ancile* from the same Yunnanese locality, is somewhat like *Holcothyris laosensis*, Mansuy.

In 1921, Commandant Dussault, working in Western Tongking, between the Red river and the Laos frontier, described a series of

[1] *Op. cit.*, Vol. XVIII, Fasc. V, p. 23, (1929).
[2] *Pal. Ind.*, Ser. XV, Vol. III, Pt. 2, pp. 57, 73, (1899).

red, sandy conglomerates with a calcareous cement, red limestones and calcareous shales. The narrow band of these red conglomerates is known as the 'Terrain Rouge', and has been found at various places in the Black river valley, to the north of Pac Ma but particularly to the south-east, indeed, in that direction the same conglomerates extend into the Samneua Province of the Laos, so that their groups of interrupted exposures stretch for at least 150 miles.[1]

The brachiopod limestones of Pac Ma, etc., Black River Valley, Western Tonking.

On the left bank of the Black river, one kilometre below Pac Ma, chocolate coloured sandstones alternate with marly beds of the same tint containing bands of limestone pebbles and passing upwards into the red conglomerate. This group is about 800 or 900 feet thick, Above it are 150 feet of calcareous shale, passing into red limestone about 300 feet thick and followed in its turn by approximately 100 feet of calcareous shale again. This red limestone is the 'Calcaire Rouge à Térébratules de Pac Ma'. The locality is also described as Ba Ma by some French writers. On the right bank of the river rises a high cliff of Palæozoic limestone. In other sections the "Terrain Rouge" rests discordantly on a sandy and shaley series with interbedded rhyolites and porphyries, presumably of Triassic age, but the relations between it and these rocks is not clear. The following fossils occur at Pac Ma and have led to the attribution of a Callovian age to at least that part of the 'Terrain Rouge' in which they occur[2] :—

Auclacothyris inflata, Mansuy.
Spiriferina lipoldi, Bittn.
Terebratula bamaensis, Mansuy.
Terebratula complanata, Mansuy.
Rhynchonella cuneiformis, Mansuy.

The two which head the list occur also at Ban O in Samneua and Fromaget's remarks regarding them, given in the preceding paragraph, apply with equal force in the present case. In addition we have here his further opinion that *Terebratula bamaensis*, Mansuy, is probably only a mutation of *Terebratula himalayana*, Bittn. and that *Terebratula complanata*, Mansuy, is merely a variety

[1] The term 'Terrain Rouge' is also used for various other formations of 'Red Beds' types in Indo-China, with which these particular rocks should not be confused.
[2] *Bull. Serv. Géol. Indochine*, Vol. X, Fasc. II, pp. 35-37, 66-67, (1921).

of *T. bamaensis.*[1] *Terebratula* (*Dielasma*) *himalayana*, Bittn., is a common species in the lower subdivision of the Himalayan Muschelkalk of Spiti, Painkhanda and Johar.[2] *Rhynchonella* aff. *cunciformis*, Mansuy, is, according to Dr. Cowper Reed, represented in my own collection from Liu-wun.

The Brachiopod Limestones of Hoang Mai, Northern Annam.

While the discovery of Upper Triassic ammonites in the brachiopod limestones of Luang Prabang showed that they could no longer remain in the Jurassic system, the additional data afforded by the Hoang Mai sections completed the stratigraphical evidence and confirmed the revised view that the Norian is their correct position in the geological scale. Near kilometre 239 of the Hanoi-Vinh railway, exposures examined by M. J. Fromaget in 1927 [3] displayed a fairly thick series of sandy shales identical with those containing *Myophoria goldfussi*, V. Alberti elsewhere in the same region and correlated with the Upper Ladinian. (*M. goldfussi* is a characteristic fossil of the dolomite-limit at the top of the German Lettenkohle, regarded by most German authorities as Keuper but by others as Muschelkalk.[4]) These sandy shales pass upwards into more or less shaley sandstone containing small ferruginous pebbles, which are followed in their turn by fairly thick masses of grey or red limestones with rounded lumps and layers of quartz of various colours. Throughout their whole thickness these limestones contain the remains of terebratulids, the commonest of which is identical with *Aulacothyris inflata*, Mansuy. Other forms include *Aulacothyris sandlingensis*, Bittn. and *A. patricia*, Bittn. of the Dachsteinkalk. All these sediments are pierced by partially brecciated, andesitic intrusions; they are folded, and support, without any doubt, in spite of a local topographical gap, the almost horizontal sandstones and shales of the Rhaetic.

In this same region, known as the Triassic 'Gulf' or 'Strait of Nghe An' and to the elucidation of which MM. Lantenois, Deprat, Jacob and Dussault have contributed, in addition to M. Fromaget, the shales with *Myophoria goldfussi* are underlaid, in conformable succession, by further shaly horizons with *Hœrnesia.* Below these again, the Middle Trias is well developed, comprising at its base limestones with *Mentzelia mentzeli*, then a thin series of

[1] *Op. cit.*, Vol. XVIII, Facs. V, p. 23, (1929).
[2] *Pal. Ind.*, Ser. XV, Vol. V, Mem. No. 2, p. 131, (1907).
[3] *Bull. Serv. Géol. Indochine*, Vol. XVI, Fasc. 2, pp. 174, 181, (1927).
[4] Traité de Geologie, Paris, p. 865, (1921).

shales with a rich fauna of ammonites attributed to the Middle Virglorian, of which *Xenodiscus middlemissii*, Diener, is very characteristic, and finally limestones and shales with various species of *Ceratites*. The base of the Trias is formed by conglomerates which unconformably overlie the older rocks. These details are added here to show that the Terebratula limestones of Hoang Mai lie at the top of a conformable sequence of marine strata, comprising most of the Triassic system. The marine deposits are confined to relatively narrow bands and pass laterally into red beds, sandstones, shales and marls of detrital or lagoonary origin which on both sides of the central chain of Annam and in many other portions of Indo-China, are, with the basal conglomerates, the only representatives of the system, conditions which I hope to show on some future occasion, are prevalent also in Central Yunnan.

Recent French investigations confirm the revised classification adopted in Indo-China.

A study of the further progress made in the exploration and classification of the Mesozoic rocks of Indo-China up to the end of 1935, reveals nothing likely to lead to modifications in the revisions which have been made. On the contrary, new evidence has been forthcoming which confirms the earlier decision to regard the true position of the formations in question as uppermost Trias. At the same time it does not simplify the difficulty of correlating them with the Shan and Yunnanese groups as represented by the Napeng beds, the Namyau series and the Liuwun limestones, though it does reinforce the case of the French writers for a thorough revision of their faunas.

A paper of M. Fromaget's published in 1935 contains his matured reflections on the stratigraphy and structural geology of Indo-China [1] and I must limit myself here to a suitable selection of the numerous observations which have since appeared up to the end of that year.

The mixed fauna and flora of the Samneua syncline.

Perhaps the most important corroboration comes from the southern part of the Military Territory of Lai Chau in Northern Tongking, where the depressed zone of the 'Samneua Syncline', (in which the Carnian is of bathyal and the Norian of neritic facies), meets the 'Crystalline Arc of Song Ma', itself covered by subcontinental Carnian and by neritic, littoral and lagoonal Norian deposits. To M. Fromaget, who surveyed it in 1935, the region

[1] *Bull. Soc. Géol. France*, 5th Ser., Tome IV, (1934).

appears as a synthesis of all that is known of these formations in Indo-China, as practically every facies previously discovered is found in close association there. To Indian geologists it is of ominous importance because of the coexistence in the same horizons of authentic Trias and even neo-Triassic forms, such as the Halobias; of forms which they have been taught to believe are Rhaetic from the Napeng fauna; of plants from the Hongay flora; and of still more recent types such as the brachiopods of Luang Prabang and Pac Ma, which the French workers provisionally correlate with those from the Namyau and Liu-wun limestones..

In this syncline the Carnian, with various characteristic ammonites, supports a series of shales containing plant remains such as *Podozamites* sp. and *Pterophyllum* cf. *bavieri*, and, in addition, a rich lamellibranch fauna. Of sixteen species identified from this, the following five are typical Napeng forms:—*Gervillia* aff. *præcursor*, *Protocardia contusa*, *Cardium nequam*, *Myophoria napengensis*, *Burmesia lirata*. Other well known Himalayan, as distinct from Shan, fossils, include *Anodontophora griesbachi*, *Lima subpunctata*, and *Halobia commata*, all from the Upper Trias. In the vicinity of Sop Cop these beds bear calcareous intercalations with *Palæocardita buruca*, as well as shaly ones with *Pecten laosensis* and rhynchonellids comparable with the Luang Prabang specimens. The intercalations, moreover, are perhaps only lateral facies indicating slightly different bathymetrical conditions.

The littoral and transgressive Norian of the Song Ma Arc is composed of sandy and marly alternations often of a pronounced detrital character, in the various members of which many Napeng fossils have been found. For example, from a series of nodular, brown, marly sandstones, situated about the middle of the group, the following have been identified, the Napeng forms being marked with an arterisk:—* *Myophoria* cf. *napengensis*, *Lima* aff. *striata*, *Lima striatoides*,* *Burmesia lirata*,* *Protocardia* cf. *contusa*, * *Pecten quotidianus*, *Anodontophora trapezoidalis*, *Halobia* aff. *lineata*, * *Denticulina mona*, *Terebratula* cf. *bamaensis*, *Ostrea* sp. Here again there is the same association of a terebratulid from the brachiopod limestones of Pac Ma with the Shan Rhaetic (?) fauna. Further to the north these Norian formations are replaced by a series of red, fossiliferous, lagoon deposits, consisting mainly of red sandstones, greenish conglomerates and marls with *Estheria minuta*.[1]

[1] *C. R. Ac. Sc.*, Tome 201, No. 19, pp. 843-845, (4th Nov., 1935).

Attention may also be invited to the recently discovered succession of littoral or very shallow sea deposits of a sandy-shaly character, believed to be of Norian age and characterized by a plenteous Napeng fauna, in the Tran Ninh region of the Upper Laos. *Cardium nequam* and *Burmesia lirata* are common fossils here. In this case too, the fossiliferous rocks pass laterally into red beds.[1]

The Napeng fauna of Tran Ninh.

Finally, the latest investigations in the Norian deposits of the Upper Laos syncline, some 50 miles to the south-south-west of Luang Prabang, though they have not revealed further exposures of the brachiopod limestones themselves, have shown the existence of sandy shales of a 'terrain rouge' type which are correlated with the red sandstones lying above them elsewhere. Interbedded with them are thin, brown shales, covered with impressions of a large species of *Gervillia* which presents remarkable affinities with *G. præcursor* of the Napeng beds.[2]

Developments in the Upper Laos syncline.

In his 'Introduction to the Tectonics of the Indosinides', a remarkably able essay on the palæo-geographical evolution of Indo-China and neighbouring countries from Permian to Liassic times, M. J. Fromaget maintains the Norian age of the deposits in question and their relations elsewhere, and as far as Indo-China is concerned there they are likely to remain. His brochure must be consulted for details of the various narrow geosynclines now mapped out, which, following the general emersion of south-eastern Asia in late Permian-early Triassic times, have opened and closed again, or otherwise modified their forms throughout the whole duration of the latter period, and of the contemporaneous gradual development of the arcs between them, culminating in the Norian, in the genesis of the mountain structure of to-day. Here will be found the most complete and logical *expose'* of the Indosino-Himalayan virgation which has yet appeared.[3]

Conditions of Norian sedimentation in Indo-China and adjacent regions.

On the general question of the Norian sedimentation, the accumulated evidence from Indo-China and elsewhere, leads to the

[1] *C. R. Ac. Sc.*, Tome 201, No. 14, pp. 563-564, (30th Septr., 1935).

[2] *Ibid.*, Tome 200, No. 24, pp. 2027-2088, (12th June, 1935).

[3] Contribution a l'Étude structurale du sud-est de l'Asie. I. Essai sur l'Evolution paleo-geographique de l'Indochine et des Contrées avoisinantes, depuis le Permien jusqu' au Lias. (Introduction à Le Tectonique des Indosinides et des Plissements plus recents), pp. 1-22, (1934).

conclusion that the earlier bathysmal deposits of the ancient depressions, as for instance, the two residual branches of the Himalayan geosyncline, were for the most part replaced by widespread sandy-shaly formations, containing the numerous shells of the littoral or partly neritic Napeng fauna, associated with various Alpine or Himalayan forms as well as with peculiar local varieties. These deposits betoken the progressive expulsion of the sea, or, in other words, general geosynclinal regression accompanied by transgression on to the abraded surfaces of the surrounding continental areas, phenomena familiar enough to geologists who have worked in the Shan States. On these grounds are explained not only the dominant lamellibranch element of the faunas, but also the detrital beds, sometimes accompanied by coal seams, which are the results of the lagoonal regime established by the continental invasion.

A little later in the Norian, certain depressions commenced to sink regularly, though with some oscillations. Sedimentation continued in the form of sands, shales and marls, but the faunas are occasionally enriched with cephalopods, while other channels, becoming deeper still, were filled with calcareous deposits containing brachiopods and corals or brachiopods and ammonites. Sediments of these types are often accompanied or followed by red shales, sandstones and marls, with or without conglomerates of either calcareous or siliceous matrix. New lagoons on the continental regions were silted up with sandy-shaly sediments and abundant vegetable debris, giving rise later to coal seams with the *Glossopteris indica* flora.

Of our region in particular M. Fromaget believes that in Norian times the Asiatic Archipelago was fringed exteriorly by a series of marine deposits, belonging, some to the "Gulf of Napeng" and the others to the Pacific ocean. The latter, which may include some at least of the Myophoria sandstones of Pahang, Padang and Singapore, and other well-known Upper Triassic occurrences of Rotti, Timor, Serang, Buru and Misol, are of no immediate concern here. The "Gulf of Napeng", he describes as an extension towards the north of the residual furrow (*sillon*) of the eastern branch of the Himalayan geosyncline, closed over the greater part of its length from the Middle Trias, and to it he attaches the Napeng beds, then probably the Namyau limestones—'which contain rhynchonellids analogous or identical with the Norian forms of Luang Prabang' and finally the Kamakala limestone of Amherst on the Burma-

Siam frontier. The Liu-wun limestones are not specified here, but there can be no question that they too would be included.

The movements of the Norian seas accompanied the orogenic paroxysms which produced the Indosinides, " chains of mountains of which the principal elements are confined to the right wing of the Virgation of the Asiatic Archipelago ". It follows that the mountain arcs of south-eastern Asia were already in existence in Upper Triassic times, and indeed it is shown elsewhere that the Himalayan movements had very little effect upon them.

I owe an acknowledgment here to M. F. Blondel, Director of the *Bureau d'Études Géologiques et Minières Coloniales*, Paris, and to Prof. Ch. Jacob, Director of the Geological Laboratory at the Sorbonne, for their kindness in obtaining and lending to me certain publications of the *Service géologique de l'Indochine*, which were not obtainable at the time in London.

V.—M. J. FROMAGET'S VIEWS ON THE POSITION OF THE NAMYAU AND LIU-WUN LIMESTONES.

In preceding paragraphs we have seen how the positions previously occupied by four great Mesozoic formations of Indo-China have been changed, in each case to the Norian; the brachiopod limestones of Pac Ma and Ban O from the Callovian, the shales with the Napeng fauna of Con Tagne and many other localities from the Rhaetic, the brachiopod limestones of Luang Prabang from the Lias and the coal and plant-bearing beds of Eastern Tongking, Phong Saly and elsewhere from the Rhaetic. I shall now review the proposal that the Namyau series and the brachiopod bed of Liu-wun should be lowered to the same division, leaving for future consideration the Napeng beds except in so far as they affect the present argument.[1]

The incomplete stratigraphical sequence.

M. Fromaget admits that in the case of these extra Indo-Chinese formations, he cannot be equally positive, until the results of further surveys are available; at the same time, such comparisons as he has been able to make hardly permit him to doubt the Norian age of both Napengs and Namyaus, while the Liu-wun beds, being entirely comparable with the latter, ought to follow their fate. He is therefore led to correlate them all, with a question mark, in the

[1] *Bull. Serv. Géol. Indochine*, Vol. XVIII, Fasc. V, pp. 19-20, 30, (1929).

same division as the displaced strata of Indo-China. He mentions the transgressive character common to all these formations and their extension over the margins of the earlier Triassic shores on to the continental borders, which is explained by a rising of the oceanic floors: extensions which are also betrayed by the absence or comparative rarity of the earlier cephalopod faunas and by the presence of the littoral conglomerates, which have sometimes advanced for quite appreciable distances into the epicontinental seas. A study of the published accounts of the stratigraphy of the Napeng beds and the Namyau series is not helpful towards a determination of their ages and no satisfactory description of their contacts has ever been given. M. Fromaget continues that, in a general way, the areas occupied by the two formations are independent, but he is impressed by the fact that they both rest on a conglomerate containing pebbles of Plateau Limestone as well as older rocks. From this point of view he finds no obstacle in regarding both the Napengs and Namyaus as synchronous lateral variations of the same formation.

The palæontological argument.

Stratigraphy furnishing no useful criteria, he is driven to rely on palæontological data to support his suggestion of their changed place in the succession, and in his opinion, as I understand it, the arguments hitherto employed have been insufficient, in that they have failed to make suitable comparison with the results obtained in neighbouring countries. The known distribution of the Napeng fauna in Yunnan, Indo-China, and Malaysia is now so wide-spread, that it cannot be discussed within the limits of this paper. In any case its suggested removal from the Rhaetic to the Uppermost Norian is a small matter compared with the jump down of thirteen geological ages proposed in the case of the Namyau series and the Liu-wun beds.

M. Fromaget recalls that S. S. Buckman attributed the fauna of the Namyau limestones to the Bathonian, more particularly from the presence of the genus *Burmirhynchia* which he rediscovered amongst the rhynchonellids of the English Middle Jurassic. To-day, he states, this argument will not suffice. In this connection Diener's opinion of correlations based on the distribution of brachiopoda is worth repeating, they

'Very generally do not keep strictly to an exact geological horizon and therefore can be used only in rare cases as reliable documents for an identification of a narrowly limited geological stage or zone'.[1]

[1] *Pal. Ind.*, Ser. XV, Vol. 1, Pt. 5, p. 56 (1903).

Dr. L. F. Spath has criticized Buckman's results recently in another connection, stating that

> 'The principles underlying his methods were so thoroughly unsound as to make it doubtful whether any of his work could be trusted '.[1]

Again, he writes,

> 'It is known that the snails from neighbouring ponds all bear the stamp of their own local habitat: and it would be easy to find individuals of sufficiently diverse aspect for separation into genera as different as some of those created by Buckman for individuals '.[2]

These quotations refer it is true, to Buckman's classification of ammonites but they certainly leave the reader in doubt whether all is well with the conclusions he drew from his multitudinous descriptions of the Namyau brachiopods.

The palæontological evidence leading M. Fromaget to his suggestions is based on the fact that the common rhynchonellids occurring with the Triassic ammonites, *Discophyllites*, etc., in the limestones of Luang Prabang, *i.e.*, *Rhynchonella pseudopleurodon*, Mansuy, and *Rh. mahei*, Mansuy, present the greatest resemblances, in the case of the first-named, with *Burmirhynchia costata*, Buckm. and *B. subcostata*, Buckm., and in the second case with *B. orientalis*, Buckm. Further, *Holcothyris angusta*, Buckm. is claimed to have close affinities with *H. laosensis*, Mansuy, from Ban O, as Dr. Cowper Reed has indeed pointed out.

Turning to the Liu-wun beds where again no precise stratigraphical indications are obtainable, M. Fromaget states that *Burmirhynchia præstans*, Reed and its six varieties from that locality, possess the same external resemblances to *Rhynchonella mahei*, Mansuy from Luang Prabang. Another species belonging doubtfully to the genus *Cryptorhynchia* is very close to *Rh. cuneiformis*, Mansuy, from Pac Ma, while in the case of *Holcothyris*, the species *H. ancile*, Reed, is very near *H. laosensis*, Mansuy, from Ban O. The lamellibranchs are dismissed with the remark that the 12 species are divided amongst 7 genera, only one of which, *Exogyra*, is unknown before the Upper Jurassic, and its presence is not considered a sufficient argument to maintain the Liu-wun beds in the Jurassic.

[1] *Pal. Ind.*, N. S., Vol. IX, Mem. No. 2, p. 759, (1933).
[2] *Ibid.*, p. 874.

VI.—CONCLUSIONS.

The disputed position of the Liu-wun beds and the Namyau series. Palæontological aspects.

It is apparent that the Liu-wun brachiopod beds are identical with at least some part of the limestones of the Namyau series of the Northern Shan States. These are now regarded by the Geological Survey of India as of Upper Jurassic age but are correlated provisionally by the *Service géologique de l'Indo-Chine* with various brachiopod-bearing limestones of Northern Tongking, Annam and the Laos, which through a revision of earlier results are now placed in the Norian. It is of importance, for the reasons given below, that this difference of opinion should, if possible, be composed, so that the picture of Indo-Chinese Mesozoic geology as a whole, of which both Yunnan and the Shan States are integral parts, may be brought as near completion as possible. As there is little hope of the collection of new evidence from Yunnan in the near future, the problem is limited to a reconsideration of the available facts from the Shan States. It is a two-fold problem involving both palæontology and stratigraphy. As regards the first, a revised and extended investigation of the fossils which have been collected from the Namyaus and related beds is essential. It is regrettable that the brachiopods alone have been studied, for large collections of lamellibranchs were in existence many years ago and have been added to periodically since then. In this suggested revision the Nahkyam fauna of ammonites and gastropods, together with the few Mesozoic fossils which have been found in the Southern Shan States, should be included.

Stratigraphical questions.

From a stratigraphical standpoint the relations of the Napeng beds and the Namyau series are of primary significance. The former, hitherto regarded as Rhætic, may eventually prove to be Norian. The Namyau and Liu-wun limestones are, according to Dr. Cowper Reed, Kimmeridgian, while Dr. Fromaget, on the other hand, thinks that they are more or less contemporaneous with the Napeng beds. La Touche thought it improbable that any considerable break took place between the deposition of the Napeng beds and the Namyau series[1]. In another place he recorded that there is no evidence of a stratigraphical break between them[2].

[1] *Mem. Geol. Surv. Ind.*, XXXIX, Pt. 2, p. 286, (1913).
[2] *Ibid.*, p. 303.

These opinions are impressive, but even comparative contemporaneity of deposition cannot be accepted without impugning the date given to the Namyau series on palæontological grounds. Buckman explained away the difficulty as—

> 'A phenomenon of deceptive conformability, or of conformability without due sequence[1]'.

But a very wide time gap has still to be accounted for.

Next comes the question of the sub-division of the series itself. Can it really be divided into two parts, as Buckman suggested and as the earlier surveys tended to imply; a lower one in which limestones predominate and an upper one built up mainly of shales ?[2] or, are the limestones more or less evenly distributed throughout its whole thickness, as some of the later maps seem to indicate ? In the latter case what are the faunal variations in the limestones of the upper and lower horizons and how do they change as the limestones themselves pass laterally into still shallower water deposits ? It may prove to have been incorrect to have regarded the whole of this great series, several thousands of feet thick, as of Jurassic age, on the strength of Buckman's determinations of a notoriously unreliable group of organisms from some scattered and strictly limited portions of it. Instead of one or more Jurassic sub-divisions, we may perhaps be dealing here with a succession of deposits, generally unfossiliferous, and mainly of detrital, lagoonal and sub-continental types, ranging over most of the Triassic and Jurassic periods.

Tectonic problems.

The rearrangement of the Brachiopod limestones and related formations in French Indo-China has led to momentous changes of opinion regarding the age of the major movements which have affected not only that country, but have at the same time involved the whole of south-eastern Asia, throughout a wide zone extending from the latitude of the Himalayas to the South China sea. We have seen in previous paragraphs how the beds in question lie in conformable sequence with older Triassic deposits and with them are often strongly folded together. In northern Indo-China they are followed discordantly by Red Beds, often of the 'grés continentaux' type, which are but little disturbed, or, if that is not the case, they support over-

[1] *Pal. Ind.*, N. S., Vol. III, Mem. No. 2, p. 4, (1917).
[2] *Mem. Geol. Surv. Ind.*, XXXIX, Pt. 2, p. 304, (1913).

thrust masses of Palæozoic rocks. Between the two formations in the first case sedimentary breccias have often been recognised. The date of this discordance is the clue to the age of a period of extremely important folding which Prof. Charles Jacob was the first to realise belonged to the Mesozoic and to which he gave the name 'les mouvements majeurs'[1]. As long as the Brachiopod limestones of Indo-China were believed to be Callovian or younger, these movements could not be regarded as any older than the Upper Jurassic and it remained for M. J. Fromaget, aided by the palæontological work of Prof. Etienne Patte and others, to work out the true position. The overlying Red Beds, conglomerates, sandstones and shales, are now known to be no older than the Rhætic, by reason of the plant remains found in them in Eastern Tongking and elsewhere, and it follows that the age of the major movements, at one time regarded as a phase of the Himalayan ones, must be placed at the summit of the Trias, or at most at the bottom of the Rhætic.

Now, in association with V. P. Sondhi, I have shown that earth movements on an epirogenic scale took place in the Southern Shan States sometime in the Mesozoic, resulting in the unusually severe crumpling of the Coal Measures there, before the Red Beds were unconformably deposited upon them.[2] While we were engaged in these surveys neither Mr. Sondhi nor myself were aware of the conclusions reached by our French colleagues in an adjoining territory. I have already stated my opinion that the age of the Coal Measures may have to be lowered from the Jurassic to at least the Rhætic and I wish to withdraw here my earlier remarks on the Cretaceous age of the Red Beds themselves.[3] A recent opportunity of examining the so-called ammonites for the first time has failed to convince me of their alleged character. The Kalaw Red Beds at the moment can only be regarded as Rhætic or later.

It has now to be decided whether the discordance of the Southern Shan States and the period of folding of which it marks the upper limit, are to be synchronized with the corresponding ones now so widely recognised in Indo-China. Whatever decision is reached on this point however, another question remains—where are the signs of the operation of these events in the Northern Shan States? They were events of regional magnitude which must have been felt

[1] *Bull. Serv. Géol. Indochine*, Vol. X, Fasc. I, p. 192, (1921).
[2] *Rec. Geol. Surv. Ind.*, LXVII, p. 236, (1933).
[3] *Ibid.*, p. 197.

there because they affected Yunnan as well and were perhaps responsible, to an extent hitherto unsuspected, for the disturbed condition, of the Liu-wun beds and the rest of the Salween valley sections. La Touche's description of the Napeng Beds is worth recalling in this connection.

'They are frequently and highly disturbed and contorted in a most irregular manner. The beds are often horizontal or only tilted for a space but within a few yards they may be violently folded and crushed, as if they had been masticated between a giant pair of jaws or passed through a pug-mill'.

He ascribed this state of these rocks to settlement caused by the gradual underground solution of the limestone floor on which they rest.[1] This is not a convincing explanation and no amount of settling of this kind could possibly account for the intense crushing and wholesale distortion of the fossils in the shales, which so greatly increased Miss Healey's difficulties in their determination.[2] I suggest that these conditions, which are also typical of similar beds in Southern Yunnan, were caused by the same movements which twisted and buckled, sheared and faulted the coal seams of the Loi-an (Kalaw) field out of any resemblance to their original shape and reduced the coal itself to powder. What portions, if any, of the rocks of the Namyau series were involved in these wide disturbances? Their limestones often dip at high angles and are sometimes vertical, but is this entirely a matter of lateral Tertiary compression, as La Touche thought.[3] The recognition in the Northern Shan States of this great discordance separating the acutely folded formations from those which have only suffered milder, later pressures, could be made to serve as a trustworthy stratigraphical datum line. It may be that the latest surveys have already supplied the answers to these and similar questions and in that case their early publication is earnestly advocated.

Palæogeographical considerations.

Agreement on the age of the Liu-wun and Namyau limestones is also desirable from a palæogeographical point of view, for they are the latest marine beds known over a region approaching continental dimensions. The proof of the Norian age of rocks which French geologists believe correspond to them has established the fact that the last marine invasion of northern Indo-China finished

[1] *Mem. Geol. Surv. Ind.*, XXXIX, Pt. 2, p. 288, (1913).
[2] *Pal. Ind.*, N. S., Vol. II, Mem. No. 4, pp. 1-2, (1908).
[3] *Mem. Geol. Surv. Ind.*, XXXIX, Pt. 2, p. 357, (1913).

with the Upper Trias. Should the beds in question have to remain in the Middle or Upper Jurassic, then it must be explained how this shallow Jurassic sea came to invade the Shan-Yunnan area and in what directions its oceanic connections lay, while to the south and south-east permanent emergence of the land had already taken place. Sir Henry Hayden believed that the latter part of the Jurassic was characterised by a gradual shallowing of the Himalayan and Tibetan seas.[1] Prof. Gregory's 'Spiti Sea' cannot have crossed Yunnan and emerged in the direction of the Gulf of Tongking as he has, shown it to do.[2] Prof. G. B. Barbour, in his modification of one of Dr. Grabau's earlier maps, shows no connection between the eastern termination of a Middle Mesozoic Himalayan sea and another which covered most of the Bay of Bengal, including the southern end of the Arakan Yoma.[3] G. Stefanini joins his Himalayan and Malaysian regions by a narrower waterway stretching almost due north and south across the eastern portion of the Bay of Bengal and beyond, which would presumably include both the Shan States and Western Yunnan.[4] Dr. C. S. Fox, remarking that information regarding the Traissic strata of Upper Burma—the Shan Plateau and the Chin Hills—is fragmentary, leaves his map in the same condition,[5] while Dr. L. F. Spath has pointed out that his marine beds in the Bay of Bengal area are Cretaceous and not Jurassic.[6] The most complete series of palæogeographical maps of South-Eastern Asia during the Mesozoic period are those of M. J. Fromaget—*Les Mers et les Continents de l'Archipel Asiatique pendant les Époques liasique et triasique*[7] and *Schemas paléogéographiques du Sud-Est de l'Asie (Permo-Carbonifère au Norien*[8] and additions will doubtless be necessary to these when the Federated Shan States, Karenni, and Upper Tenasserim, not to mention Siam, come to be completely surveyed. It remains to add that

[1] A Sketch of the Geography and Geology of the Himalaya Mountains and Tibet, p. 254, (1907).

[2] *Quart. Journ. Geol. Soc.*, Vol. LXXXVI, Pt. 2, p. xci, (1930).

[3] The Structural Evolution of Asia in "the Structure of Asia," p. 197, (1929).

[4] Molluschi e Brachiopodi Calloviani del Caracorum Spedizione Italiana de Fillippi nell' Himalaia, Caracorum e Turchestan Cinese (1913-1914), Ser. II, Vol. VI, p. 177, (1928).

[5] *Mem. Geol. Surv. Ind.*, LVIII, Pl. X, (1931).

[6] *Pal. Ind.*, N. S., Vol. IX, Mem. No. 2, p. 825, (1933).

[7] *Bull. Serv. Géol. Indochine*, Vol. XVIII, Fasc. V, Plate, (1929).

[8] Contribution a L'Etude structurale du sud-est de l'Asie. 1. Essai sur L'Evolution paleo-geographique de l'Indochine et des Contrées avoisinantes, depuis le Permien jusqu' au Lias. (Introduction á Le Tectonique des Indosinides et des Plissements plus recents), Plates, (1934).

while marine Liassic faunas have so far been found no nearer to the Shan States or Yunnan than Southern Annam and Cochin China, there is perhaps the possibility of their occurrence in other portions of the geosynclinal areas, though on the whole the period seems to have been one of continental conditions in Indosinia generally.

The contrasted phyto-geographical provinces.

The parts of the Shan States and Yunnan in which the Namyau series and the Liu-wun beds occur are of extraordinary interest in that they lie in the narrow zone which separated two wide-spread and strongly contrasted phyto-geographical regions. This has been explained by Prof. T. G. Halle, as follows:—

'As far as we know at present the Arcto-Carboniferous flora of China extended in the early Permian in a south-westerly direction as far as Yunnan and the intervening distance separating the two floras is thus not great. The exploration of south-western Yunnan and Upper Burma may be expected to throw some more light on the relations between the two phyto-geographical regions. Since the Arcto-Carboniferous region reaches as far south as Sumatra, any barrier that can be imagined to account for the contrast between the two floras ought to have had a north and south extension; in the first place one might think of a connection between the eastern part of the Himalayan geosyncline and the sea in the region of the present Bay of Bengal '.[1]

The nearest known occurrences of the *Gigantopteris* flora in Chinese territory lie in Eastern Yunnan and the extreme south-western corner of Szechuan, 300 to 350 miles from the Burma frontier, but the recent discovery of *Gigantopteris nicotinæfoliæ*, Schenk., in the Nam Ou valley of the Northern Laos, brings the flora to within under 150 miles of the Southern Shan States. When the many similarities which existed between both Palæozoic and Mesozoic conditions in these two adjoining areas are considered it seems to me reasonable to expect that *Gigantopteris* itself will be found in the Shan States sooner or later. In the beds of the Nam Ou valley there is also the earliest immigrant from the Gondwanas proper—*Schizoneura gondwanaensis*, Feist., associated with a distinctly Triassic plant *Neuropteridium* aff. *polymorphum*, and the occurrence generally is believed by M. Fromaget to prove that land connections were definitely established between the two continents in Lower Triassic times.[2] Prof. B. Sahni has concluded that the Shan States Mesozoic flora as a whole does not show any obvious

[1] *Pal. Sinica*, Ser. A, Vol. 2, Fasc. I, p. 290, (1927).
[2] *C. R. Ac. Sc.*, Tome 197, p. 341, (20th July, 1933).

affinity with any of the known Indian Upper Gondwana floras[1] and, although his full results remain to be published, the evidence available at present tends to show that while at the beginning of the Trias, floral migration was taking place from the *Glossopteris* to the *Gigantopteris*-bearing regions, at its close, or possibly a little later still, the tide had set more strongly in the opposite direction from China to the Shan States, for some of the conifers from the Kalaw (Loian) coalfield have fairly close Chinese relations.[2]

The eastern coast of Gondwanaland.

Prof. Halle thinks that the abnormal north-south boundary line between these two floral regions may be found in some way connected with the tectonic features, an idea which Prof. B. Sahni has recently elaborated by the suggestion of a wide oceanic belt of separation which was later closed by horizontal Wegenerian drift,[3] a possibility mentioned earlier by Cotter in another connection.[4] These are matters outside the limits of our present discussion, but Prof. Sahni's plea for investigations along the old Gondwana coast line in the Nepal-Assam-Burma region merit the strongest support. As regards the latter in particular, the resurvey of the Mogok Stone Tract commenced by myself and continued by A. K. Banerji, E. L. G. Clegg and L. A. N. Iyer, has proved that the crystalline rocks of that region, with probably their extensions through Möngmit into the hills of the Burma-China frontier, are chiefly representatives of types well known in Southern India; that the area in question is in fact an outlying portion of Peninsular India, separated from the main mass as the central, crystalline core of Assam is detached and that there exists here another isolated piece of Gondwanaland. Further, there is no reason to suppose, as far as existing knowledge teaches, that this particular fragment, whatever may have happened to the foundered section between, has had a different geological history to that of the greater part of the Indian peninsula itself; possibly it has never been totally submerged since pre-Cambrian times.

To the east and south-east of this part of the old continent lay the shallow sea in which the Napeng beds, the Namyau series and the Liu-wun limestones were formed. Their deposition took place

1 *Pal. Ind.*, N. S., Vol. XI, p. 116, (1931).
2 *Ibid.*, p. 116, footnote.
3 *Current Science*, Vol. IV, No. 6, pp. 4-5, (1935).
4 Notes on the Geological Structure and Distribution of the Oil-bearing Rocks of India and Burma. World Petroleum Congress. Preprint No. 168, pp. 7-9, (1933).

comparatively close to the land, closer in fact than any other Secondary rocks known or likely to be discovered. Their conglomerates are inshore, littoral and beach deposits while their faunas and general lithology alike reveal their true character. The red sandstones and shales of the higher parts of the Namyau series point to the generation of lagoonal conditions by the silting or slow dessication of a shallow strait or gulf, to which their salt occurrences are also due. In addition to the surface of Gondwanaland on the west, a continental regime had been established on the east, and marine deposition was confined to a narrow channel in part of the earlier but by that time largely obliterated Permian geosyncline. The presence of carbonaceous shales, coaly matter, coal seams and plant remains, sometimes in conjunction with marine organisms, amongst the Mesozoic rocks of the Shan States, are convincing additional proofs of the proximity of the land and in these terrestial remains it is not unreasonable to expect representatives of both great floras, for the locus is in a most convenient intermediate position.

Thirty-six years ago P. N. Dutta collected plant remains from the Napeng beds of Kyinsi (Hsunoi), close to the confluence of the Nam Hsim and Nam Tu rivers near Bawgyo,[1] but they still remain undescribed. It is also probable that various occurrences which have previously been classed with the underlying Plateau Limestone, belong in reality to the Mesozoic rocks. These include the following :—

(1) The greatly contorted and in places vertical shales in a railway cutting, three miles east of Kyaukme Station, which according to La Touche, contain a phyllopod resembling *Estheria mangiliensis*, Rupert Jones, from the Panchet beds of the Indian Gondwanas. together with plant remains.[2] This appears to be the same locality as one termed "Lwekaw" by Dutta and from which he collected both ferns and bivalves.[3]

(2) The coaly layers traced for some distance by Dutta, near Manpwe, a station on the railway between Hsipaw and Lashio.[4]

[1] *Gen. Rep. Geol. Surv. Ind.*, p. 114, (1899-1900).
[2] *Mem. Geol. Surv. Ind.*, XXXIX, Pt. 2, p. 255, (1913).
[3] *Gen. Rep. Geol. Surv. Ind.*, p. 113, (1899-1900).
[4] *Mem. Geol. Surv. Ind.*, XXXIX, Pt. 2, p. 255, (1913).

(3) The coal seams examined by myself, nine miles south of Wetwin in Hsipaw State.[1]

At first sight there may appear to be little in common between the Liu-wun beds of Yunnan and the plant remains of problematical Mesozoic age in the Northern Shan States, but all these matters are closely inter-related and any advance in our knowledge of one of them will assist towards a better comprehension of the others, at the same time making clearer the relations between the Gondwanas and the Indosinias, as the contemporary continental formations of more eastern regions are now termed.

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[1] *Rec. Geol. Surv. Ind.*, XLV, p. 112, (1915).

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VIII. EXPLANATION OF PLATES.

Plate 26.—Geological map of parts of the Shan States and Yunnan. (Scale, 1 inch= 32 miles).

Plate 27.—Outline sketch map showing approximate localities of brachiopod beds in Yunnan, the Shan States and Indo-China, (shaded area in Shan States is Namyau series) (Scale, 1 inch=160 miles, approx.).

ON THE GEOLOGICAL AGE OF THE NAMYAU, LIU-WUN AND NAPENG BEDS AND OF CERTAIN OTHER FORMATIONS IN INDO-CHINA.

BY M. R. SAHNI, M.A. (CANTAB.), D.SC. (LOND.), D.I.C., *Assistant Superintendent, Geological Survey of India.*

CONTENTS.

I—INTRODUCTION.

In a valuable contribution to the geology, not only of the Shan States of Burma, but also to that of Indo-China and neighbouring territories, Dr. Coggin Brown[1] has focussed attention upon the question of the age of various brachiopod bearing formations and certain other beds which, according to the views of French geologists[2] in Indo-China, are of much older age than is attributed to them by workers on Indian geology. Thus, they have proposed to lower the age of the Namyau series, containing a prolific brachiopod fauna composed of species of *Holcothyris* and *Burmirhynchia*, and of the Liu-wun brachiopod beds, containing an identical fauna, from the Bathonian (Middle Jurassic) to the Norian division of the Upper Trias. It is proposed, similarly, to lower to the same horizon the Napeng beds of Rhaetic age, in spite of the presence in them of the zone fossil *Pteria* (*Avicula*) *contorta*, Portlock. There are other formations in Indo-China, now placed in the Norian, with which these Shan States formations, hitherto assigned to the Middle or

[1] *Rec. Geol. Surv. Ind.*, 71, Pt. 2, pp. 170-216, (1936).
[2] Fromaget, J., *Bull. Serv. Géol. Indochine*, Vol. XVIII, Fasc. 5, pp. 19-20, 30, (1929).

Upper Jurassic, are correlated, so as to give, it is stated, a connected picture of the early Mesozoic geology of these regions.

Although Dr. Brown's leanings to the French view are evident from a perusal of his paper, he has made it clear that the question of the age of these formations in the Shan States and Yunnan is still an open one, and that he has taken no particular side himself.

The object of writing this note is to examine how far these views, based in the writer's opinion upon mistaken hypotheses and comparisons, are tenable. But I would also like to make it clear that my own definite views are expressed only in so far as the Namyau series, the Liu-wun and the Napeng beds are concerned.

II.—EVIDENCE IN FAVOUR OF A JURASSIC AGE FOR THE NAMYAU SERIES.

The assignation of a Bathonian age to the Namyau series is due to Buckman[1], who first described a large collection of brachiopods made by La Touche from the Namyau beds. Although Buckman's palæontological methods have frequently been criticised, I believe with some reason, and his stratigraphical theories regarded as fanciful, I think his broader generalisations nevertheless are of value.

Views of S. S. Buckman.

His arguments for assigning a Bathonian age to the Namyau beds are threefold and to these I shall add such other evidence as has become available from the more recent investigations of other workers, since the publication of Buckman's Burma memoir. It may be stated at once that later evidence tends to decrease rather than increase the age of these beds and is, therefore, still more opposed to the French view.

The evidence deduced by Buckman may now be summarised.

(1) Only two brachiopod genera, *Holcothyris* and *Burmirhynchia*, have been found in the Namyau series. There are no known brachiopod faunas, either European or Indian, with which the Namyau terebratulids and rhynchonellids could be compared, except in a general way. In fact the genus *Holcothyris* has not, so far, been found outside the Sino-Burmese region. How then are we to correlate species of this genus with European or other forms, in order to fix their horizon in geological chronology? Buckman supplies

[1] Buckman, S. S., *Pal. Ind.*, N. S., Vol. III, pp. 216-18, (1917).

the answer, not convincing in itself, but I may be permitted to quote him in full :

'Taking the Terebratulids first, there is a resemblance to a new series of Bathonian forms, *Avonothyris* ; but it is only a general resemblance, not identity........ this evidence can only be considered as indirect.......... '.

'In the English strata, the genera *Ptychtothyris*, *Avonothyris* and *Cererithyris* are obviously successive developments from a sulcate ancestor. There is a geological gap separating *Ptychtothyris* from *Avonothyris*—the Fuller's Earth and Great Oolite (Upper Vesulian and Lower Bathonian), there is another gap separating *Avonothyris* from *Cererithyris*—the Forest Marble (Bathian). Now it might be suggested that these gaps were filled by other developments from the sulcate ancestor, and that as *Holcothyris* is such a development there is a probability that its position in time corresponds with one of these gaps. Did it occupy the time which preceded or succeeded *Avonothyris*[1]'.

Leaving out the details, reference to which can be made in Buckman's memoir, a comparative morphogenetic study of these genera, according to Buckman, indicates that '*Holcothyris* falls into a gap between *Ptychtothyris* and *Avonothyris*[2]', and if the geological horizon of *Holcothyris* synchronises with this gap, the genus would be of Bathonian age.

It is true that this argument involves more than one supposition, but time and again intermediate stages of known forms have been predicted, looked for and discovered. The instance of *Holcothyris* may be classed in that category, though it is not claimed that the genera mentioned stand in a true phyletic series.

(2) More convincing and direct is the evidence supplied by species of the genus *Burmirhynchia*. This genus has been recorded in the European Bathonian strata, but no identical species have been found in the two areas. This perhaps is not so surprising, for terebratulid and rhynchonellid faunas are often singularly restricted in the distribution of their species. I quote from Buckman again :

'As to the Rhynchonellids, there is a general resemblance to the European species of the Bathian, say, from Great Oolite to Cornbrash ; but on analysis of internal structure there is found to be only particular, that is, generic resemblance in a few cases—to certain Rhynchonellids of the Great Oolite (Bathian) of England and France, more or less related to *B. hopkinsi*, Davidson, but mainly new species.

The geological position, therefore, which is indicated by the generic affinities of the Rhynconellids is fairly confirmatory of that suggested by a more general likeness of the Terebratulids ; it points to Bathian near about the Bradford Clay[3]'.

[1] *Loc. cit.*, pp. 217-218.
[2] *Loc. cit.*, p. 218.
[3] *Loc. cit.*, p. 217.

The evidence gleaned from the geological distribution of the genus *Burmirhynchia*, therefore, also leads to the same conclusion.

(3) Curiously enough there is no correspondence between the brachiopod fauna of Kutch and of the Namyau series of the Shan States. In fact the Namyau series shows a greater correspondence to the European than to the western Indian Jurassic, for at least one genus is common to the two regions. This, however, may be due equally to zoogeographical reasons as to paucity of collection. On the other hand, the genera *Kutchithyris*, *Flabellothyris*, *Cryptorhynchia* and *Kutchirhynchia* of the Putchum beds are found at various horizons in the Bathonian of Europe, containing species of *Burmirhynchia*. Indirectly we may, therefore, also correlate the Namyau series with the Putchum beds, and arrive at a Bathonian age for the former.

It will be noticed that while Buckman's arguments do not unquestionably denote a Bathonian age for these beds, it can at least be said without doubt that we are here dealing with Jurassic and not with Triassic forms.

But this is not the whole argument.

Later views.

(4) Working on Dr. Coggin Brown's collections from the Liu-wun brachiopod beds (Yunnan), Dr. Cowper Reed pointed out that 'the similarity of the brachiopod fauna of these Liu-wun beds with that of the Namyau Beds of Burma is striking, but in the case of the other fossils the evidence does not point to the same age as Buckman deduced from the brachiopods, for they have Oxfordian or Kimmeridgian affinities, and some of the species are almost indistinguishable from common European Upper Jurassic forms'.

However, he states that 'probably they came from a higher horizon than the Oxfordian series..........On the whole Kimmeridgian age may be ascribed to the fauna[1]'.

In the case of a still later collection made by Dr. Cowper Reed himself from the Northern Shan States he writes:

'There does not seem any sufficient reason to revise the previous conclusion that the position of these beds is in the Upper rather than in the Middle Jurassic, though possibly they are Oxfordian rather than Kimmeridgian and Grabau, who considers that the faunas of the Yunnan and Burmese beds are identical, is apparently of opinion that the beds are of Bathonian age, as indeed Buckman concluded, but beds in the Malay Archipelago containing some of the same brachiopods are mentioned as probably of Oxfordian age[2]'.

[1] Reed, F. R. C., *Pal. Ind.*, N. S., Vol. X, p. 255, (1927).
[2] Reed, F. R. C., *Rec. Geol. Surv. Ind.*, LXV, p. 186, (1931).

Cowper Reed, therefore, also ascribes a Jurassic (it is true later than Bathonian) age to a part of the Namyau series.

III.—EVIDENCE FROM OUTSIDE THE SINO-BURMESE REGION

Views of Miss Muir-Wood.

More recently Miss H. M. Muir-Wood has described a Jurassic fauna from the Attock district, Punjab, containing species of *Burmirhynchia*. These forms, comparable with the Namyau species and collected by Messrs. Lahiri and Iyengar, are *Burmirhynchia* cf. *namyauensis*, Buckman, *Burmirhynchia* cf. *parva*. B, *Burmirhynchia* cf. *turgida*, B, and they establish an important link with the contemporaneous Mesozoic faunas of the Shan States.

According to Miss Muir-Wood the age of these beds may be later than Bathonian. She states :

'The presence of species of *Burmirhynchia* comparable to those of the Namyau beds of the Northern Shan States which S. S. Buckman assumed to the Bathonian but which may be Callovian or later in age, is of interest, since no similar forms occur at Kachh. Species of *Burmirhynchia* occur however, at Shekh Budin, and will probably be found in the Salt Range Jurassic............similar forms also occur in the Callovian beds of Arabia, ...Species of *Burmirhynchia* occur also in the Bathonian of Transjordan and in the Callovian of Somaliland[1].'

From this extensive distribution of the genus *Burmirhynchia*, (and the evidence of the co-existing fauna) in the Callovian and Bathonian beds of different parts of the world, pointed out by Miss Muir-Wood and others[2], it can only be concluded that the genus is at any rate not older than the Bathonian.

The attribution of a Triassic age to beds with *Burmirhynchia*, provisionally suggested by the French writers in Indo-China, does not, therefore, appear convincing.

It may be noted, though it is immaterial to the problem we have in hand, that the genus *Holcothyris*, which occurs frequently in association with *Burmirhynchia* in the Shan States, has not so far been discovered in the Indian region, even at localities where *Burmirhynchia* has been recorded.

Finally I have in my own collections from the Northern Shan States a number of terebratulids that are certainly distinct from

[1] Muir-Wood, H. M., *Pal. Ind.*, N. S., Vol. XX, Mem. No. 6, L. (1936), in press.
[2] Weir, J., Monogr. Geol. Dept., Glasgow Univ., pp. 1-63, Pls. I-V, (1929). Diaz-Romero, Palaeont. Italica, Vol. XXXI, pp. 1-61, Pls. I-III, (1931).

Recent collections by the author.

Holcothyris. They bear a striking resemblance to certain Jurassic forms, while other shells I have provisionally referred to *Cererethyris*. Unfortunately I have not been able to devote attention to detailed comparisons of all these forms, though there is no doubt that the specimens are of Jurassic and not of Triassic age.

IV.—ARE THE LIU-WUN BRACHIOPOD BEDS OF NORIAN AGE.

The Liu-wun brachiopod beds contain a fauna identical to that of the Namyau series, and, as pointed out by Coggin Brown[1], the following species are common to the two formations—*Holcothyris pinguis*, Buckman, *H. rostrata*, B. *H. subovalis*, B, *Exogyra eminens*[2], Reed, and *Exogyra bruntrutana*, Thurm., *Pecten* (*Synclonema*) *luchiangensis*, Reed, and *Pecten* (*Camptonectes*) *lens*, Sow. There can therefore be no doubt regarding the correlation of these two brachiopod bearing horizons, namely, the Liu-wun and Namyau formations taken as a whole.

I propose now to examine the nature of the palæontological evidence in support of a Norian horizon attributed to these formations by the French geologists and deduced by them from a comparative study of the faunas occurring in the brachiopod bearing beds of Indo-China and the Burmese region.

In my opinion the analogy is based upon an erroneous hypothesis, and the use of the term ' Brachiopod beds ' in a comparative sense, for some of the formations in Indo-China is in itself a misnomer. It tends (perhaps it is meant) to imply identity with the brachiopod bearing Namyau series. The mere presence of brachiopods in two formations is of no significance in correlation, unless it can be shown that the species are identical. Indeed, as I shall later show ammonites really constitute the more important element in the fauna of certain Indo-Chinese formations which may, therefore, more aptly be termed ammonite (and not brachiopod) bearing beds.

Among others, the following species occur at Liu-wun—*Burmirhynchia praestans*, Reed, *Cryptorhynchia* aff. *cuneiformis*, and *Holcothyris ancile*, Reed. Referring to this formation the following remarks appear :

' Turning to the Liu-wun beds, where again no precise stratigraphical indications are obtainable, Mr. Fromaget states that *Burmirhynchia praestans*, Reed, and

[1] Brown, J. Coggin, *Rec. Geol. Surv. Ind.*, 71, p. 183, (1936).
[2] This species is now referred to *Gryphaea* by Dr. L. R. Cox.

its six varieties possess the same external resemblances to *Rhynchonella mahei*, Mansuy, from Luang Prabang. Another species belonging doubtfully to the genus *Cryptorhynchia* is very close to *Rh. cuneiformis*, Mansuy, from Pac Ma, while in the case of *Holcothyris* the species *H. ancile*, Reed, is very near *H. laosensis*, Mansuy from Ban O. The lamellibranchs are dismissed with the remark that twelve species are divided amongst seven genera, only one of which, *Exogyra*, is unknown before the Upper Jurassic and its presence is not considered a sufficient argument to maintain the Liu-wun beds in the Jurassic[1]'.

The above statement is in my opinion somewhat categorical and unconvincing, for against it are the arguments placed by Buckman, the evidence deduced by Cowper Reed from the Namyau faunas elsewhere, the distribution of identical faunas in the younger Jurassic beds of India, Somaliland and Arabia, as shewn by Miss Muir-Wood and, finally, the presence in my own collections from the Namyaus (which are by correlation of the same age as the Liu-wun beds) of forms which are undoubtedly of Jurassic age.

Furthermore, it will be observed that of the species mentioned above and occurring at Liu-wun, there is not a single instance of complete identity with forms from Luang Prabang, Ban O, or Pac Ma, localities that are considered by the French geologists to be of Norian age. The relationship is only expressed by such terms as " greatest resemblance ", " close affinities ", " same external resemblances ", but there is no identity of species in any case, except in that of the not very precisely identified form *Rh.* aff. *cuneiformis*, to which reference will be made again.

It may, therefore, be said that no association of any of the definitely known Namyau forms with faunas from Indo-Chinese localities that are placed in the Trias by French geologists, has been demonstrated.

It is true that when Buckman attributed a Bathonian age to the Namyau series he had only generic similarity with European forms to depend upon. However, later work has amply confirmed that if Buckman made a guess, it was an inspired one.

I may perhaps be permitted to comment upon another argument, brought forward by Fromaget[2] and referred to by Coggin Brown, regarding the lamellibranch fauna of the Liu-wun beds (see page 8). It may be stated that if all the lamellibranch genera are such as have a range extending into the Trias, the presence of *Exogyra* may really

[1] Brown, J. Coggin, *Loc. cit.*, p. 202, (1936), Fromaget, J., *Bull. Serv. Géol. Indochine*, Vol. XVIII, Fasc. 5, p. 31, (1929).
[2] *Ibid.*, p. 31.

be the crucial link in the chain of evidence establishing a Jurassic age for these beds. The other six genera prove nothing positive either way, and they at least do not prove that the beds could not be Jurassic. The evidence of *Exogyra* is therefore also in favour of the official view of the Geological Survey of India that the beds are Jurassic.

Finally, it is obvious that although the Liu-wun beds can be correlated with the Namyau series they cannot at present be compared with the Indo-Chinese formations, and if the latter are Triassic, as claimed by the French geologists, they can hardly be contemporaneous with the Liu-wun beds.

We now come to a consideration of the age of another important formation in Indo-China, the Luang Prabang beds[1].

These beds are described as the 'Brachiopod Limestone of Luang Prabang'. As I have previously pointed out, this term is a misnomer, for ammonites and not brachiopods form the more important element of this fauna, once supposed to be of Liassic age. As pointed out by Coggin Brown, Fromaget himself attributes 'no importance to the brachiopods which make up the bulk of the fauna, in spite of the fact that certain Rhynchonellids are admitted to be identical or to present close affinites with examples from the Namyau and Liu-wun limestones[2]'.

It is stated (after Fromaget) that 'common rhynchonellid species occurring with the Triassic ammonites *Discophyllites, etc.*, in the limestone of Luang Prabang, *i.e.*, *Rhynchonella pseudopleurodon*, Mansuy, and *Rh. Mahei*, Mansuy, present the greatest resemblances, in the case of the first named with *Burmirhynchia costata*, Buckman, and *B. subcostata*, Buckm. and in the second case with *B. orientalis*, Buckm. Further, *Holcothyris angusta*, Buckm. is claimed to have close affinities with *H. laosensis*, Mansuy, from Ban O, as Dr. Cowper Reed has indeed pointed out[3]'.

It will be noticed again that of the brachiopod species occurring at Luang Prabang mentioned by Dr. Brown there are no rhynchonellid species identical with either the Namyau or Liu-wun brachiopods, except a species doubtfully identified as *Rh.* aff. *cuneiformis*. There are general resemblances between the Shan and Indo-Chinese forms, it is true, but not in a single instance have they been shown to be completely identical. And except in the case of *Holcothyris laosensis* from Ban O, none of the brachiopods are known even to belong definitely to genera occurring in the Shan States.

[1]Jacob, C. and Dussault, L., *Bull. Serv. Géol. Indochine*, Vol. XIII, Fasc. IV, p. 52, (1924).

[2]*Loc. cit.*, p. 190.

[3]*Loc. cit.*, p. 202.

It therefore follows that the Triassic ammonites from Luang Prabang are not associated with definitely known Namyau or Liu-wun forms, and unless an extensive association of such forms is shown, the age of the Namyau beds cannot be lowered to the Norian, nor can the Luang Prabang beds be compared with the former.

The brachiopod limestones of Ban O and Pac Ma, formerly classified as Callovian, are now placed in the Norian, but since there are no forms in the Ban O or Pac Ma limestones that are identical with the Namyau brachiopods, a comparison with the latter is similarly futile. The occurrence of *Holcothyris laosensis* at Ban O is not sufficient to institute a correlation and to state that Namyau forms are associated with Triassic forms at Ban O. In the present instance there is at best only generic and not specific identity. And in the writer's opinion a critical study of this species may ultimately reveal that it cannot be referred to *Holcothyris* at all.

The conclusion is again the same, that no definite association of Namyau forms with undoubted Triassic forms in Indo-China has been shown to exist.

V.—THE AGE OF THE NAPENG AND OTHER BEDS.

I now come to the second proposal, namely, to lower the Napeng beds of Rhaetic age and other formations in Indo-China containing a Napeng fauna, to be Norian. This of course is not so serious a matter as the lowering of the Namyaus to the Trias, but it merits discussion.

The evidence that militates against this presumption appears to me to be quite strong. Apart from the presence of several forms like *Cassianella* cf. *subspeciosa*, Martin, *Myophoria* cf. *emmerichii*, Winkler, *Isocyprina ewaldi*, Borneman, that are closely related to Rhaetic species, there are at least three other species *Pteria* (*Avicula*) *contorta*, Portlock, *Grammatodon lycetti*, Moore, and *Gervillia praecursor*, that are definitely European Rhaetic forms, and one of these, *Pteria* (*Avicula*) *contorta*, Portlock, is the zone fossil that definitely stamps the age of the Napeng beds as Rhaetic. This identification has also been supported by Kossmatt, so that there could be no doubt as to its authenticity.

According to the French[1] view certain beds at Con Tagne containing a typical Napeng fauna and even " an *Avicula* related to the

[1]Jacob, C. and Dussault, L., *Bull. Serv. Géol. Indochine*, Vol. XIII, Fasc. IV, p. 43, 1924).

zone fossil *A. contorta,* Portlock" are also referred to the Norian though it is stated that 'from the standpoint of official Indian geology they are indubitably of Rhaetic age[1]'.

It would appear that if the view of the French geologists is accepted, the value of an important zone fossil like *Pteria* (*Avicula*) *contorta* must be nil. If, on the other hand, the identification of the species from the Napeng beds of the Shan States and the Con Tagne beds of Indo-China is correct, and there appears no reason to doubt it, for Kossmatt[2] also confirms it, the Rhaetic age of the Napeng beds cannot be easily impugned.

Dealing with the fauna of the Samneua syncline it is stated by Coggin Brown (according to Fromaget's views) that 'here again there is the same association of a terebratulid from the brachiopod limestones with the Shan Rhaetic (?) fauna[3]'.

This needs comment. As I have pointed out on a previous page, the association of a terebratulid with this fauna is of no significance at all,—there may be a score or more of terebratulid species associated with the Shan Rhaetic fauna,—but the question is, are they identical with the terebratulids from the Namyau series and the Liu-wun brachiopod beds of the Yunnano-Burmese area, or even with those occurring in the ammonite and brachiopod bearing beds of Luang Prabang, containing cephalopods of Triassic age?

In the present instance only a single terebratulid—*Terebratula* cf. *bamaensis*, has been found associated with a Shan Rhaetic fauna and even this is not identical with any of the forms recorded from the various brachiopod horizons in the Shan States. The conclusion is once again inevitable that the Napeng beds, the Con Tagne and other beds in Indo-China containing Rhaetic fossils cannot be correlated with the Namyau or Liu-wun beds and that no case has been made out for regarding all these formations as contemporaneous.

My own view is that in the case of the Indo-Chinese formations described as brachiopod bearing beds, lower horizons are represented than those of the Red Beds of the Shan States and Yunnan, that is, the Namyau and Liu-wun formations. And if it has been found necessary by Fromaget and others to lower the age of some of these Indo-Chinese beds, formerly placed in the Lias or in the Callovian, a case has hardly been made out to bring down with it

[1] *Loc. cit.*, p. 191.
[2] In La Touche, *Mem. Geol, Surv. Ind,*, XXXIX, p. 289, (1913).
[3] *Loc, cit.*, p. 197.

the horizons of the Shan Mesozoic formations in the face of multifold faunal evidence.

The question is of importance from another view-point, for it will affect the age attributed to earth-movements in this region. However, this question has been dealt with more fully by Dr. Coggin Brown[1] and I shall not discuss it further.

Finally, I would mention another question brought forward by Coggin Brown regarding the sub-division of the Namyau series into a lower and an upper division—the Namyau limestones and Namyau shales respectively. My survey of almost contiguous areas to those mapped by La Touche and others has shown that this division is non-existent.

I have to thank my colleague, Mr. E. R. Gee, for valuable suggestions in the preparation of this paper.

Summarised, the main conclusions are as follows :—

VI.—SUMMARY.

(i) The Liu-wun beds contain an identical fauna to that of the Namyau series and are contemporaneous with the latter.

(ii) Neither the Namyau nor Liu-wun formations contain any fossils that are definitely known to be of Triassic age.

(iii) On the other hand, definitely known forms of Jurassic—Bathonian to Kimmeridgian, ages have been recorded from these formations. The beds are, therefore, not older than the Bathonian, and in any case cannot be referred to the Trias.

(iv) None of the Indo-Chinese formations contain species that can be definitely said to be identical with those from the Namyau or Liu-wun beds. Therefore, at present , a correlation between the latter two and the Indo-Chinese formations can hardly be suggested.

(v) The Napeng beds are of Rhaetic age. The Con Tagne beds in Indo-China must be similarly classified on account of the presence of *Pteria* (*Avicula*) *contorta*, Portlock, the zone fossil of the Rhaetic, and of a fauna identical to that of the Napeng beds.

(vi) Lower horizons appear to be represented in Indo-China than in the Yunnano-Burmese area. At present we have not sufficient data to institute comparisons between the faunas of the two regions. When our knowledge of the Upper Triassic faunas of Yunnan and neighbouring territories increases such comparisons may become possible.

[1] *Loc. cit.*, p. 204.

VII.—POSTSCRIPT.

Since this paper went to the press my attention has been drawn to a recent contribution by Dr. Cowper Reed[1], describing certain lamellibranchs from the Namyau series. Dr. Reed has provisionally distinguished two horizons, namely, the Cornbrash and the Bathonian on the basis of the lamellibranchs.

This is of interest since, in the General Report for 1936, when referring to certain brachiopods collected by me from Hsai Hkao, in the Northern Shan States, it was stated that 'the terebratulids from Hsai Hkao appear to indicate a Cornbrash date'.[2]

With regard to assigning definite horizons to the faunas from the Namyau and other beds, some doubt is bound to remain till extensive collections from them have been described. Thus, in the case of the Mesozoic bed of East Africa, Dr. Cox finds 'it impossible to discriminate between the Bathonian and Callovian from the evidence of the gastropods and lamellibranchs alone'. This fact has been emphasised by Dr. Reed who further states[3] 'much less, therefore, can we draw final conclusions from the lamellibranchs alone in the collection'.

Dr. Reed's description of the lamellibranchs, however, leaves no doubt as to the Jurassic age of at least part of the Namyau series, and confirms the broader conclusions arrived at from a study of the branchiopods alone, from the same series elsewhere. The Norian-age theory of the Namyau and Liu-wun beds can, therefore, hardly be maintained, even on the evidence of the lamellibranchs, whose investigation Dr. Coggin Brown has rightly advocated.[4]

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[1] Reed, F. R. C. *Ann. Mag. Nat. Hist.*, Ser. 10, Vol. XVIII, pp. 1-28, Pls. 1-2, (1936).
[2] General Report for 1930, *Rec. Geol. Surv. Ind.*, LXV, Pt. 1, p. 88, (1931).
[3] *Loc. cit.*, p. 3.
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MISCELLANEOUS NOTE.

Quarterly Statistics of Production of Coal, Gold and Petroleum in India : January to March, 1936.

Coal.

—	January.	February.	March.	Quarterly total for each Province.
	Tons.	Tons.	Tons.	Tons.
Assam	21,338	17,020	16,382	54,740
Baluchistan	253	250	505	1,008
Bengal	581,756	699,213	620,850	1,901,819
Bihar and Orissa . . .	1,113,954	1,222,154	1,096,234	3,432,342
Central Provinces . . .	145,288	149,687	127,236	422,211
Punjab . . .	13,280	13,391	15,451	42,122
TOTAL .	1,875,869	2,101,715	1,876,658	5,854,242

Gold.

—	January.	February.	March.	Quarterly total for each Company.
	Ozs.	Ozs.	Ozs.	Ozs.
The Mysore Gold Mining Co., Ltd.	8,163	7,655	8,160	23,978
The Champion Reef Gold Mines of India, Ltd.	5,884	5,519	5,881	17,284
The Ooregum Gold Mining Company of India, Ltd.	4,185	4,180	4,175	12,540
The Nundydroog Mines, Ltd.	9,504	8,935	9,444	27,883
TOTAL .	27,736	26,289	27,660	81,685

Petroleum.

—	Crude Petroleum.	Total gasolene from natural gas.*
	Gallons.	Gallons.
Assam	16,235,091	*Nil.*
Burma	66,402,103	1,937,563
Punjab	1,439,440	118,171
TOTAL .	84,076,634	2,055,734

* These figures represent the total amounts of gasolene derived from natural gas at the well-head. Of these amounts, a portion is sold locally as 'petrol' and the remainder is mixed with the crude petroleum and sent to the refineries. The figures given in the two columns, therefore, together represent the total 'raw products' obtained. These remarks apply to the similar totals quoted in previous *Records.*

A. M. HERON.

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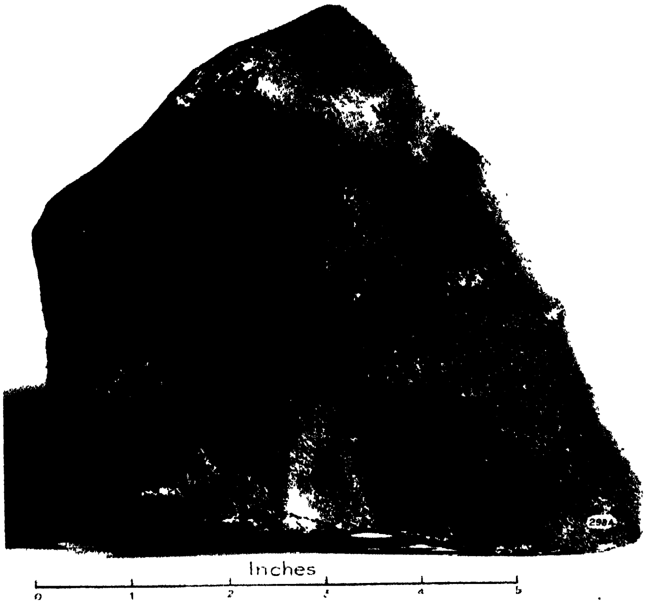
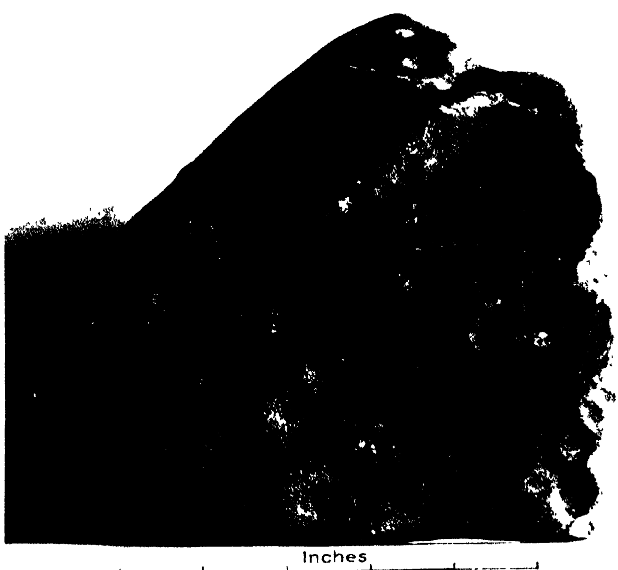


FIG 1.



P. L. Dutt., Photos. FIG. 2. *G. S. I., Calcutta.*

THE PERPETI METEORITE.

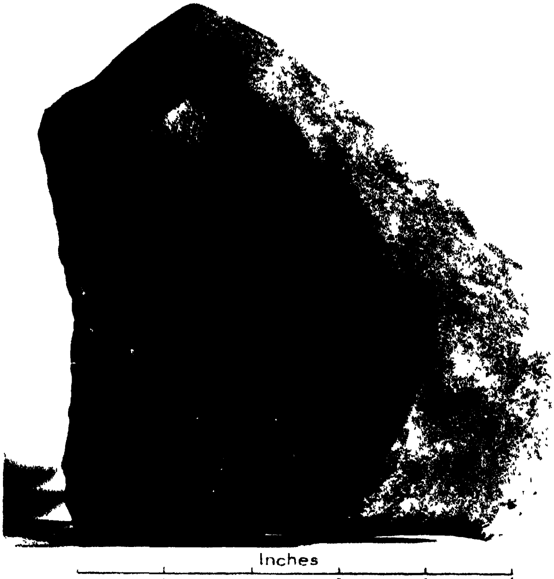


FIG. 1.

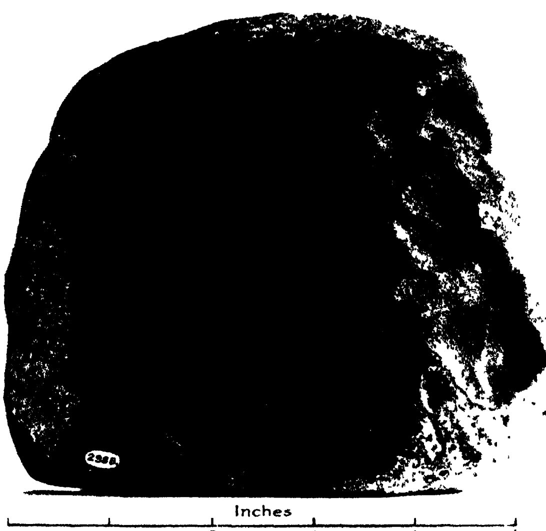


FIG. 2.

P. L. Dutt, Photos. *G. S. I., Calcutta.*

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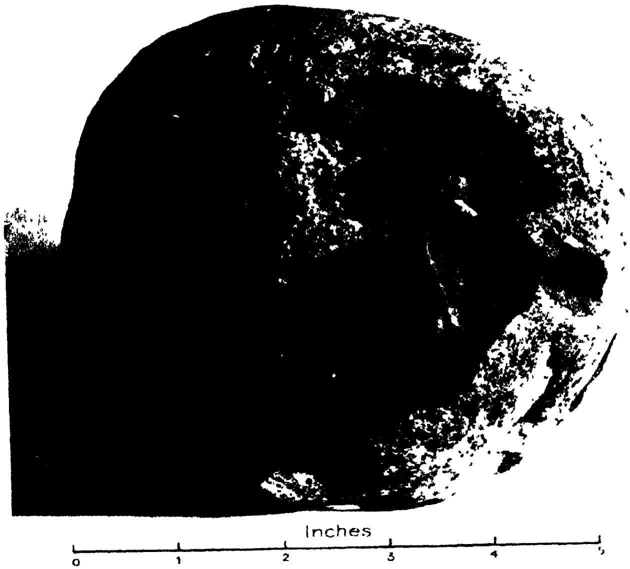

FIG 1 298 B

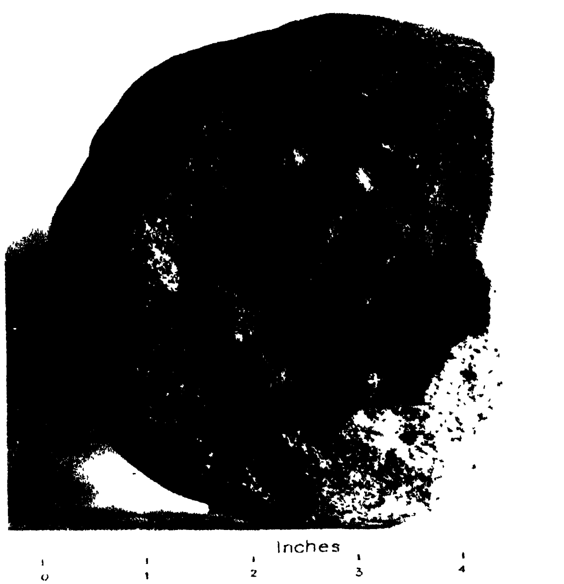

FIG. 2. 298 B.

P. L. Dutt, Photos. *G. S. I., Calcutta.*

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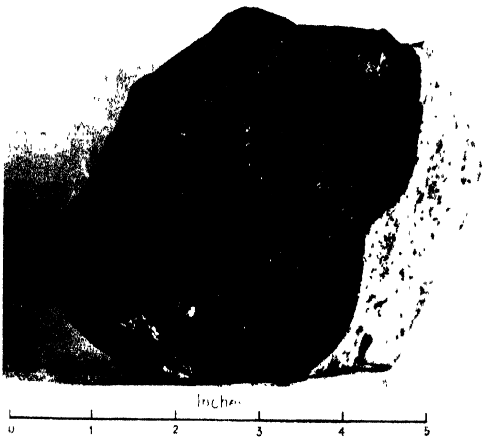

FIG 1. 298 C.

FIG. 2 298 C.

FIG. 3. 298 C.

FIG. 4. 298 C.

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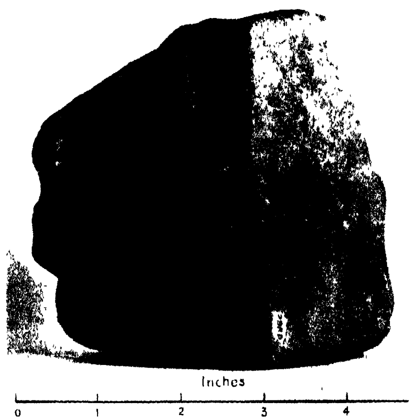

FIG. 1. 298 D.

FIG 2 298 D

FIG. 3. 298 D.

FIG. 4. 298 D.

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FIG. 1. 298 E.

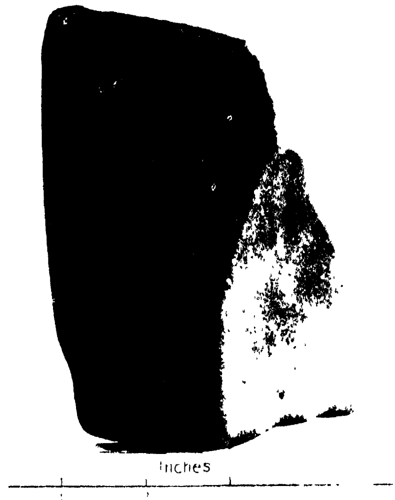

FIG. 2. 298 E

FIG. 3. 298 E.

FIG. 4. 298 E.

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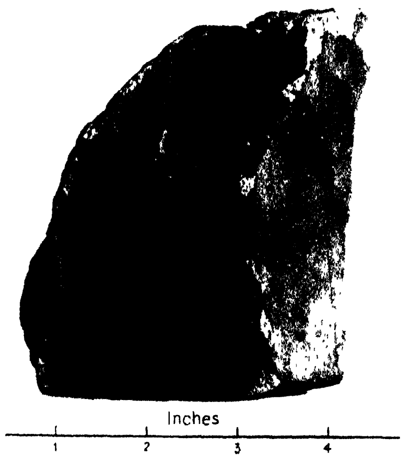

FIG. 1. 298 F.

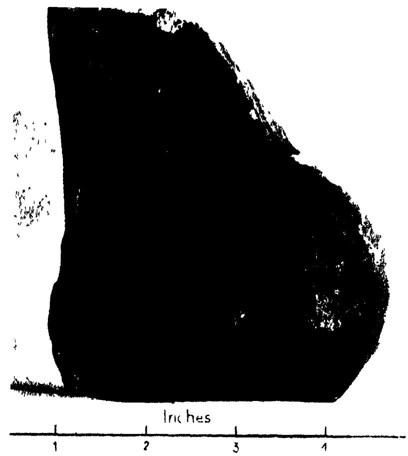

FIG 2 298 F

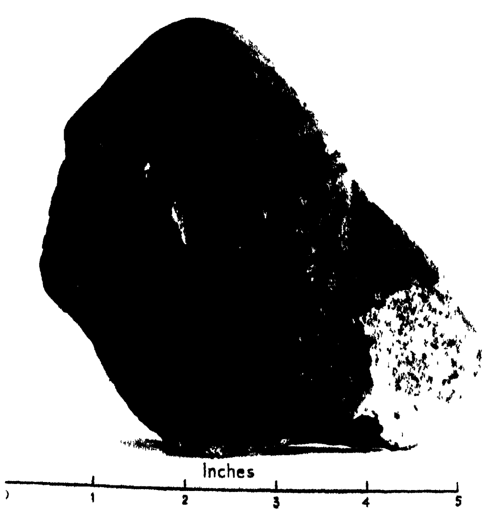

FIG. 3. 298 F.

FIG. 4. 298 F.

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FIG. 1. 298 G.

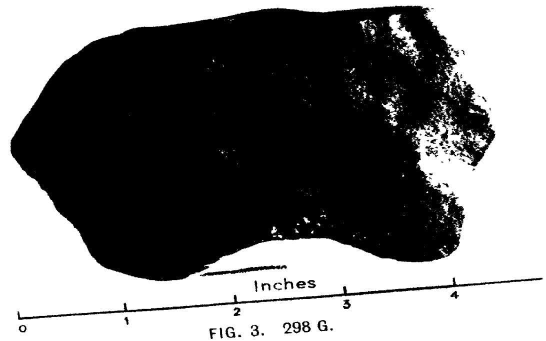

FIG. 3. 298 G.

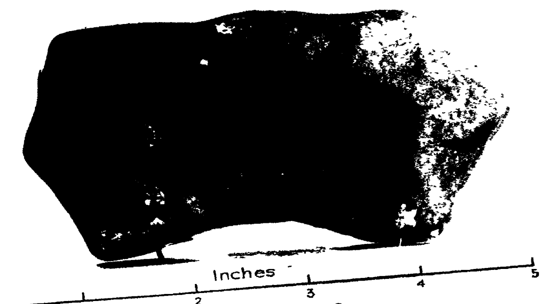

FIG. 4. 298 G.

FIG. 2. 298 G.

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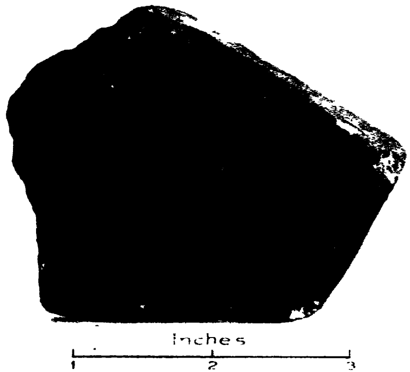

FIG. 1. 298 H.

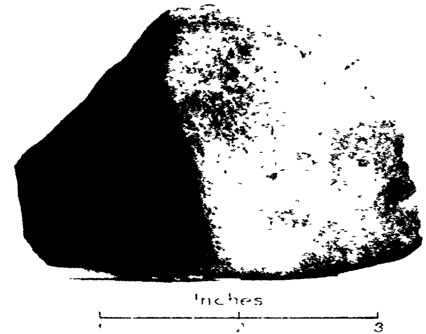

FIG. 2. 298 H

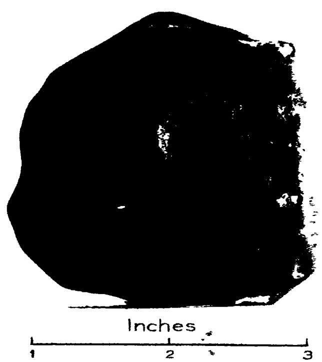

FIG. 3. 298 I

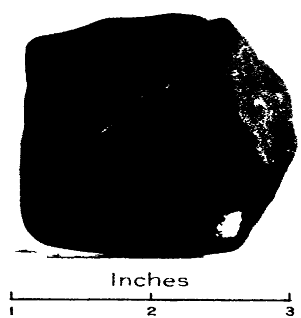

FIG. 4. 298 I.

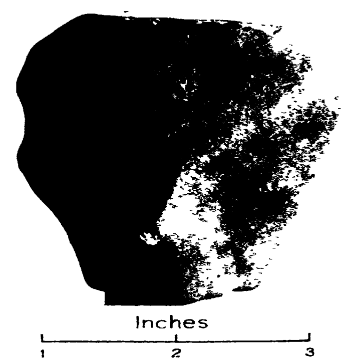

FIG. 5. 298 I.

THE PERPETI METEORITE.

P. L. Dutt, Photos

G. S. I. Calcutta.

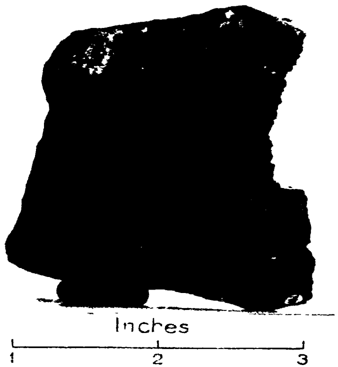

FIG. 1. 298 J.

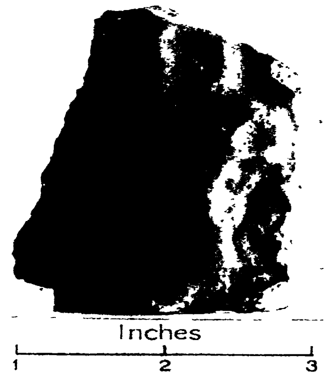

FIG. 2. 298 J.

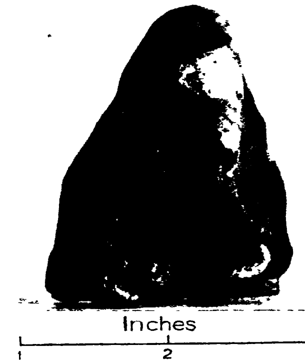

FIG. 3. 298 J.

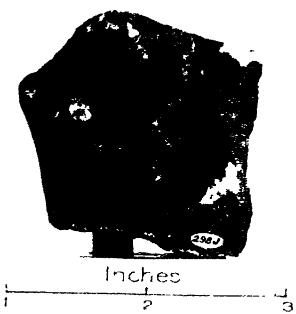

FIG. 4. 298 J.

FIG 5. 298 K.

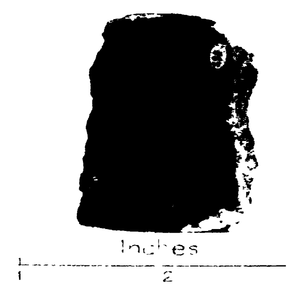

FIG. 6 298 K.

THE PERPETI METEORITE.

P. L. Dutt, Photos

G. S. I., Calcutta.

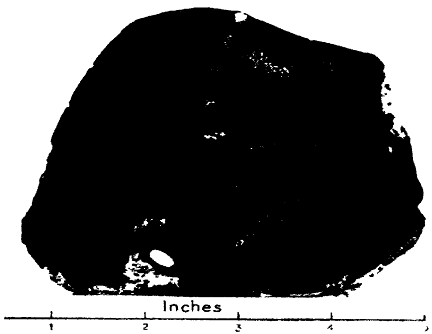

FIG. 1 298 L.

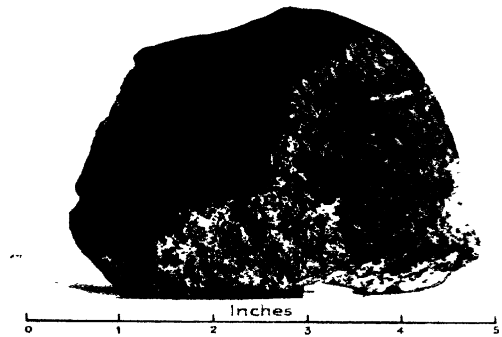

FIG. 2. 298 L.

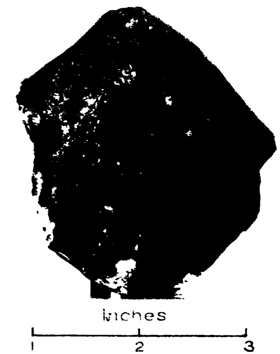

FIG. 3. 298 M.

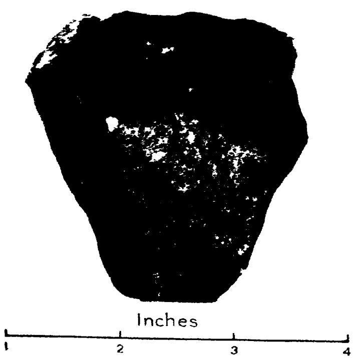

FIG. 4. 298 M.

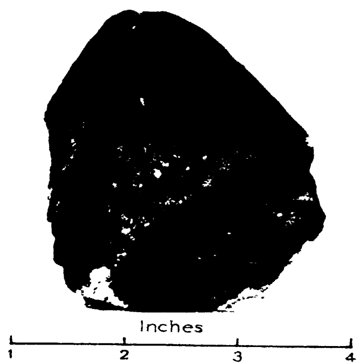

FIG. 5. 298 M.

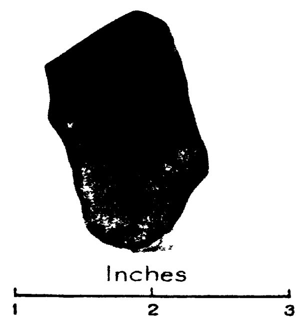

FIG. 6. 298 N.

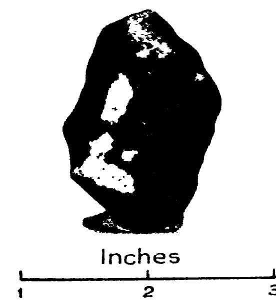

FIG. 7. 298 N.

P. L. Dutt, Photos.

THE PERPETI METEORITE

G. S. I. Calcutta.

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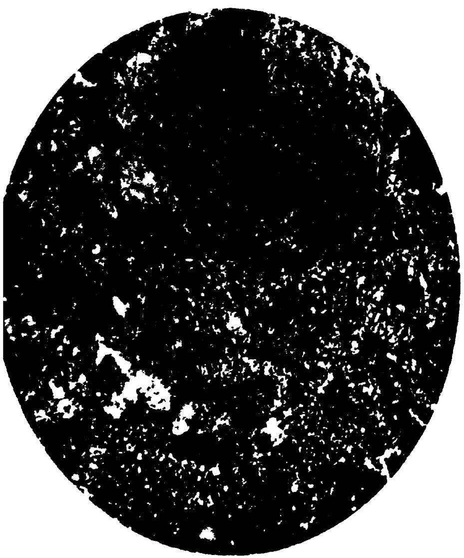


FIG. 1 (× 16).

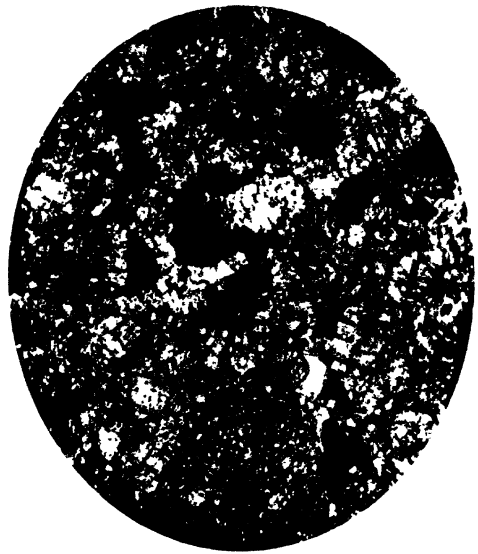


FIG. 2 (× 36).

FIG. 3 (× 36).

P. L. Dutt, Photomicros

G. S. I., Calcutta

THE PERPETI METEORITE.

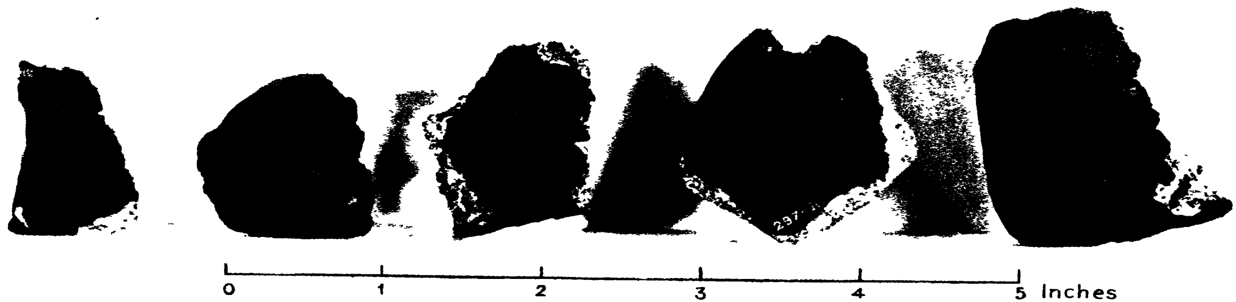


FIG. 1. TIRUPATI METEORITE (297), FRONT VIEW OF THE PIECES.

P. L. Dutt, Photos.

G. S. I., Calcutta

FIG. 2. TIRUPATI METEORITE (297), BACK VIEW OF THE PIECES.

R. B. Connell, Photo. *G. S. I., Calcutta*

THE BAHJOI METEORITE BEFORE IT WAS CUT.

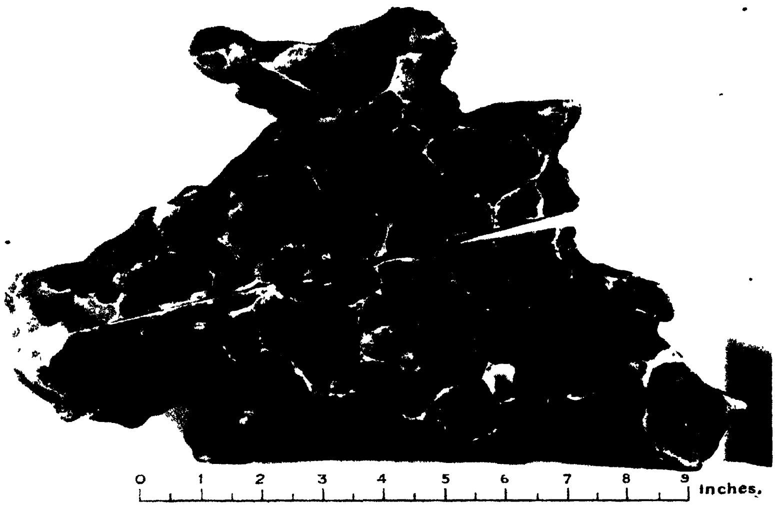
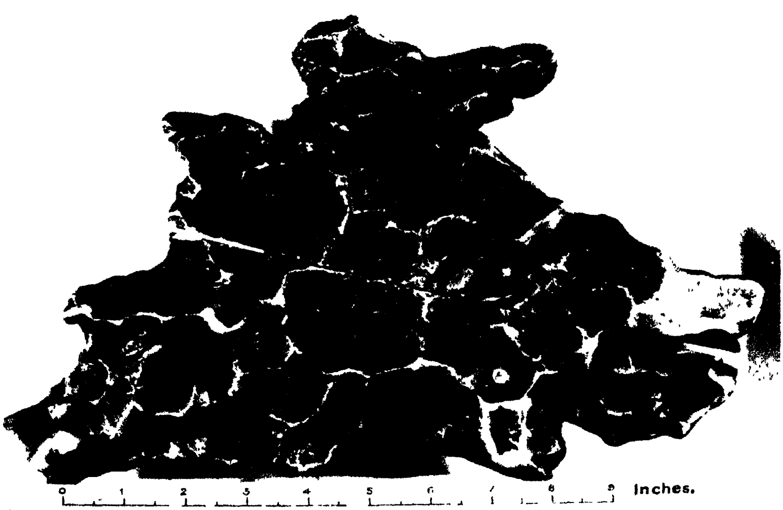


FIG 1. BAHJOI METEORITE, FRONT VIEW.

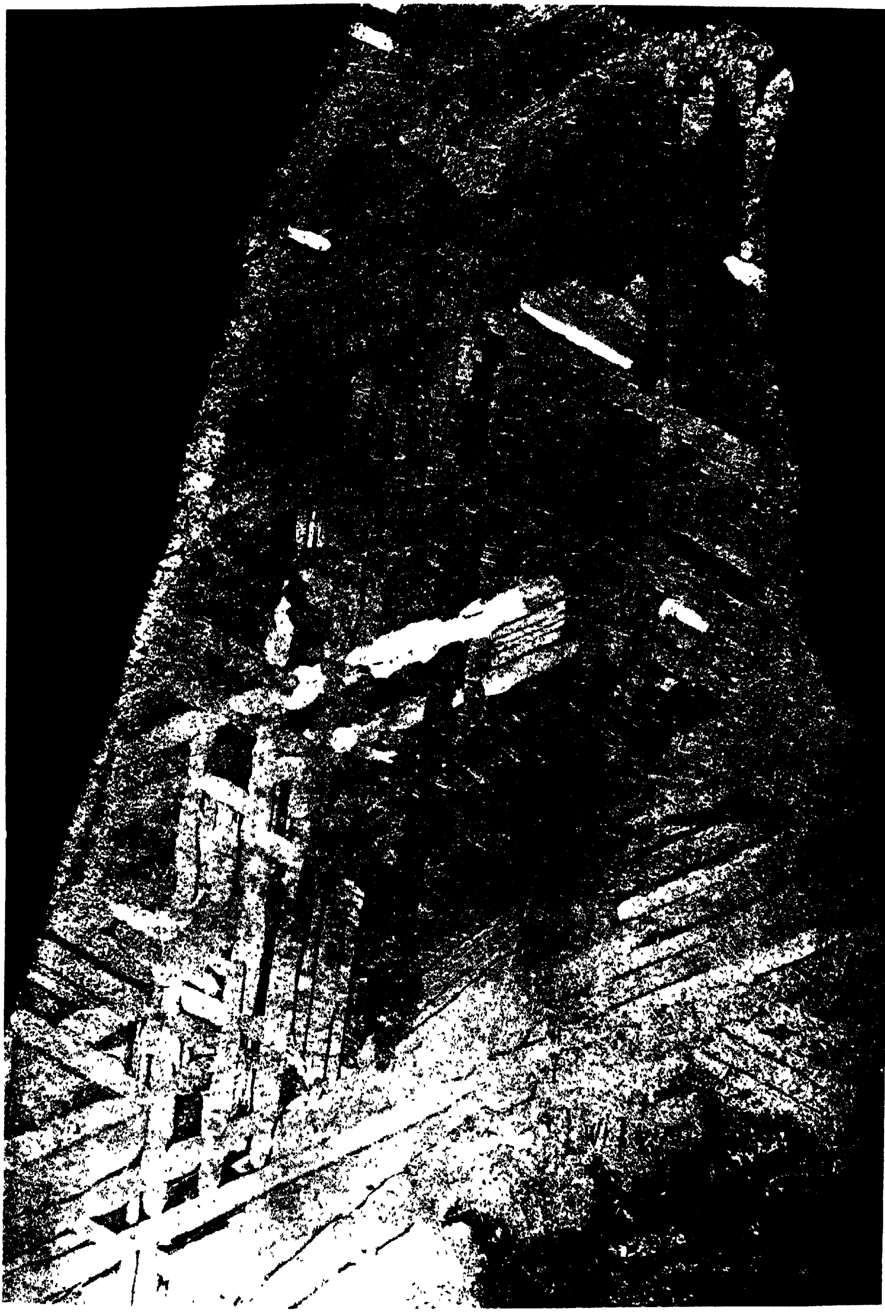


P. L. Dutt, Photos. *G. S. I., Calcutta.*

FIG. 2. BAHJOI METEORITE, BACK VIEW.

S. N. Das, Photo. G. S. I., Calcutta.

ETCHED FACE OF THE BAHJOI METEORITE (× 4·2).



S. N. Das, Photo. *G. S. I., Calcutta.*

ANOTHER PART OF THE ETCHED FACE OF THE BAHJOI METEORITE (× 2·5).

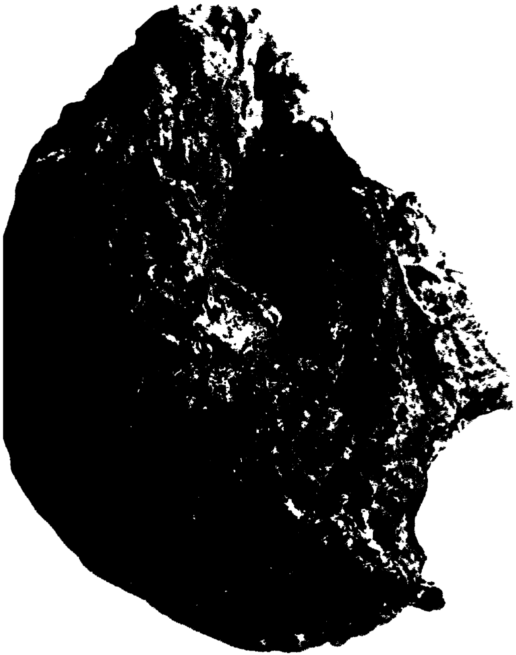


FIG. 1.

FIG. 2.

FIG. 3.

S. N. Das, Photos

G. S. I., Calcutta.

OSTREA (CRASSOSTREA) GAJENSIS, VRED., FROM NEAR BARIPADA.

Fig. 1. Left valve, external view; Fig. 2. Left valve, internal view (another specimen); Fig. 3. Right valve, internal view (another specimen).

(All figures slightly reduced).

Fig. 1.

Fig 3.

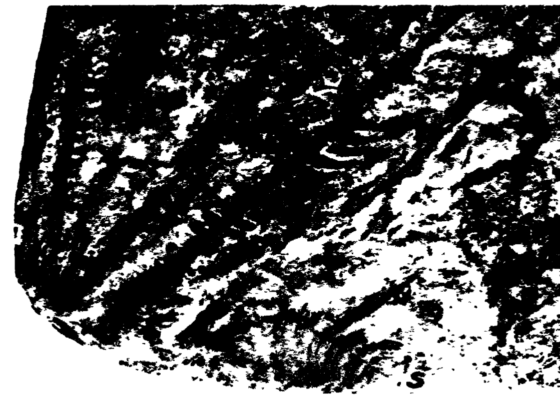


Fig. 2.

Fig. 5

Fig. 4 (×ca 2).

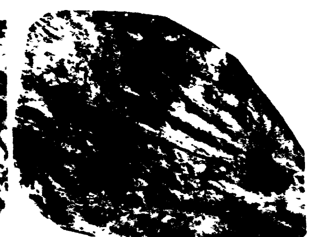


Fig. 6.

Fig. 7.

K. N. Kaul, Photos

MATONIDIUM INDICUM, *sp. nov.* (nat. size).

G. S. I., Calcutta.

Fig 5.

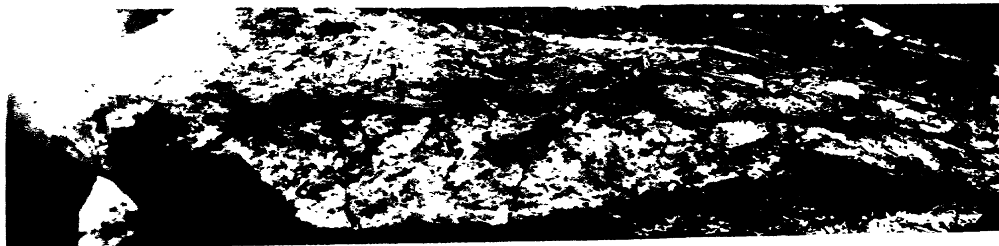


Fig 2 (slightly reduced)

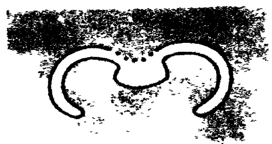


Fig. 6 (×ca 15)

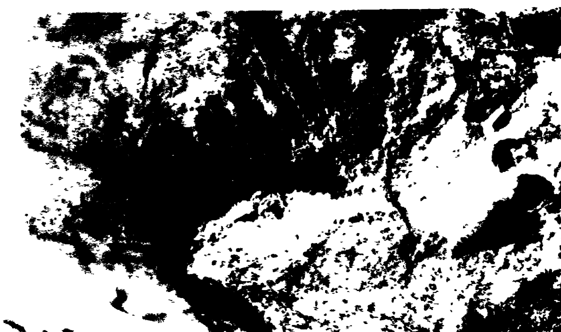


Fig. 3 (×2½).

Fig. 4

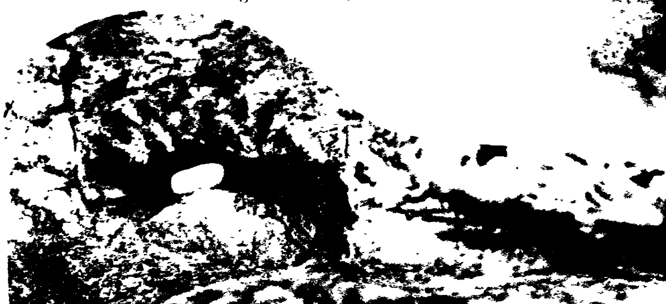


Fig. 1 (×1½).

K. N. Kaul, Photos.

MATONIDIUM INDICUM, *sp. nov.*

G. S. I., Calcutta

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Fig. 4.

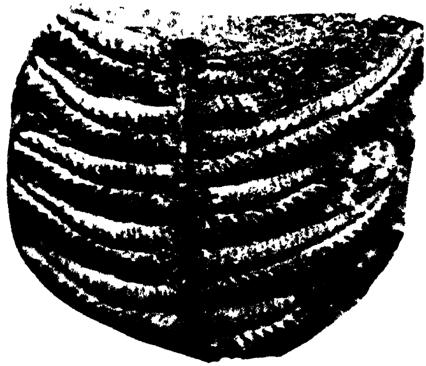


Fig. 2 (×3)

Fig. 5

Fig. 3 (×7).

Fig. 1 (×2).

K. N. Kaul, Photos.

G. S. I., Calcutta

FIGS. 1—4. MATONIDIUM INDICUM, *sp. nov.*

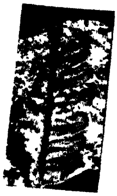


FIG. 1.

FIG. 2.

FIG. 3.

FIG. 9.

Fig. 8 (× 3)

Fig. 10 (× 3).

FIG.7 (× 2).

Fig 4 (× 3)

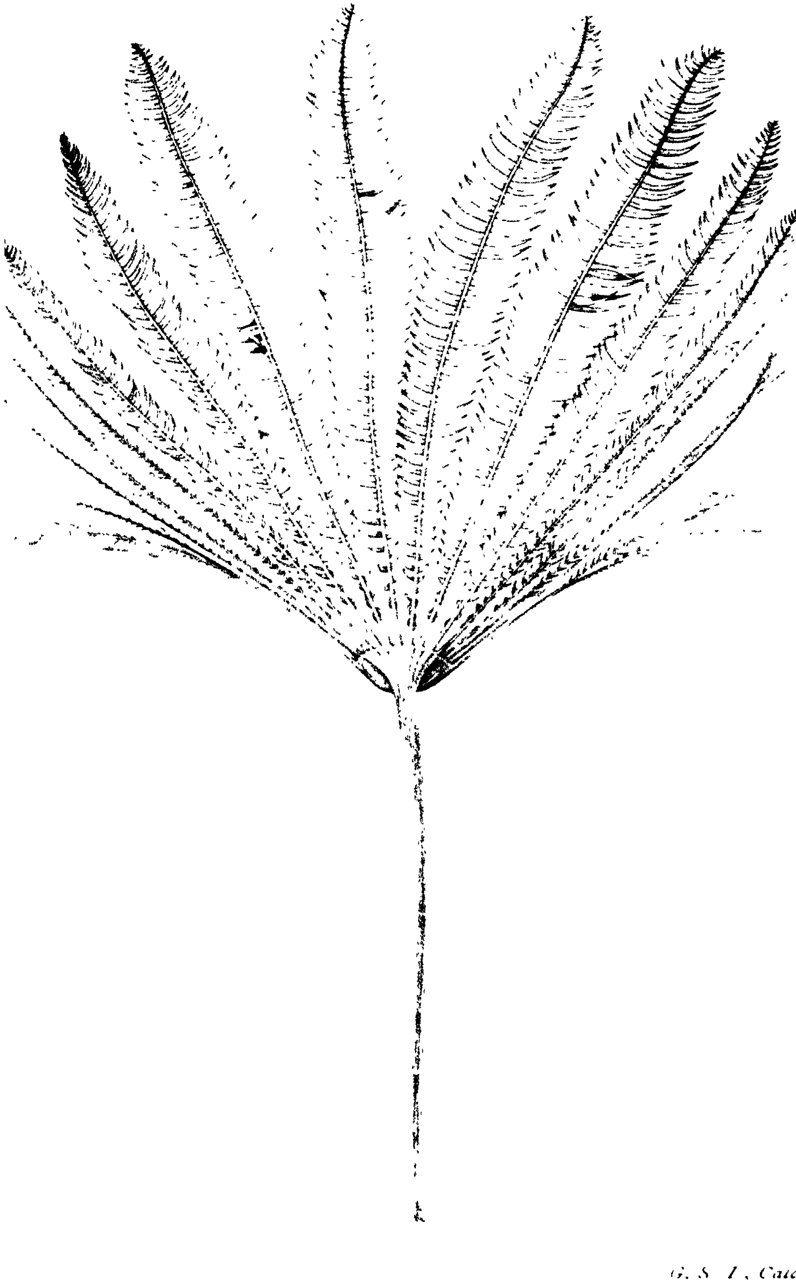
Fig. 6 (× 12).

K. N. Kaul, Photos.

Fig. 5 (× 5).

G. S. I. Calcutta

FIG. 1—6. WEICHSELIA RETICULATA.
FIG. 7. ? WEICHSELIA RETICULATA.
FIG. 8. SPHENOPTERIS *sp*
FIG. 9. ? SPHENOPTERIS *sp.*



G. S. I., Calcutta

MATONIDIUM INDICUM, sp. nov.

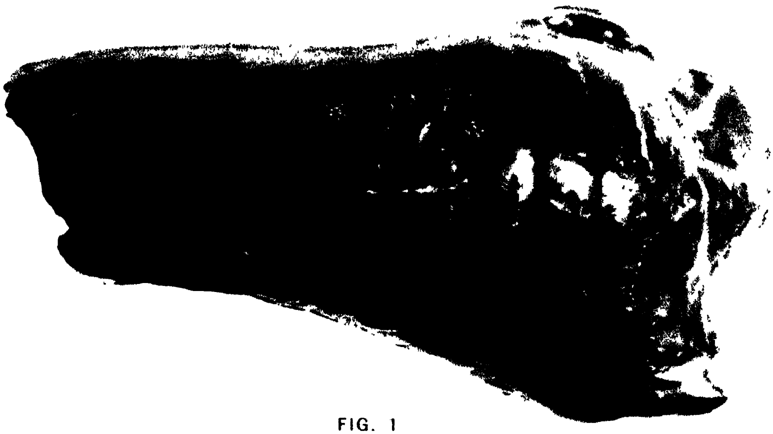


FIG. 1

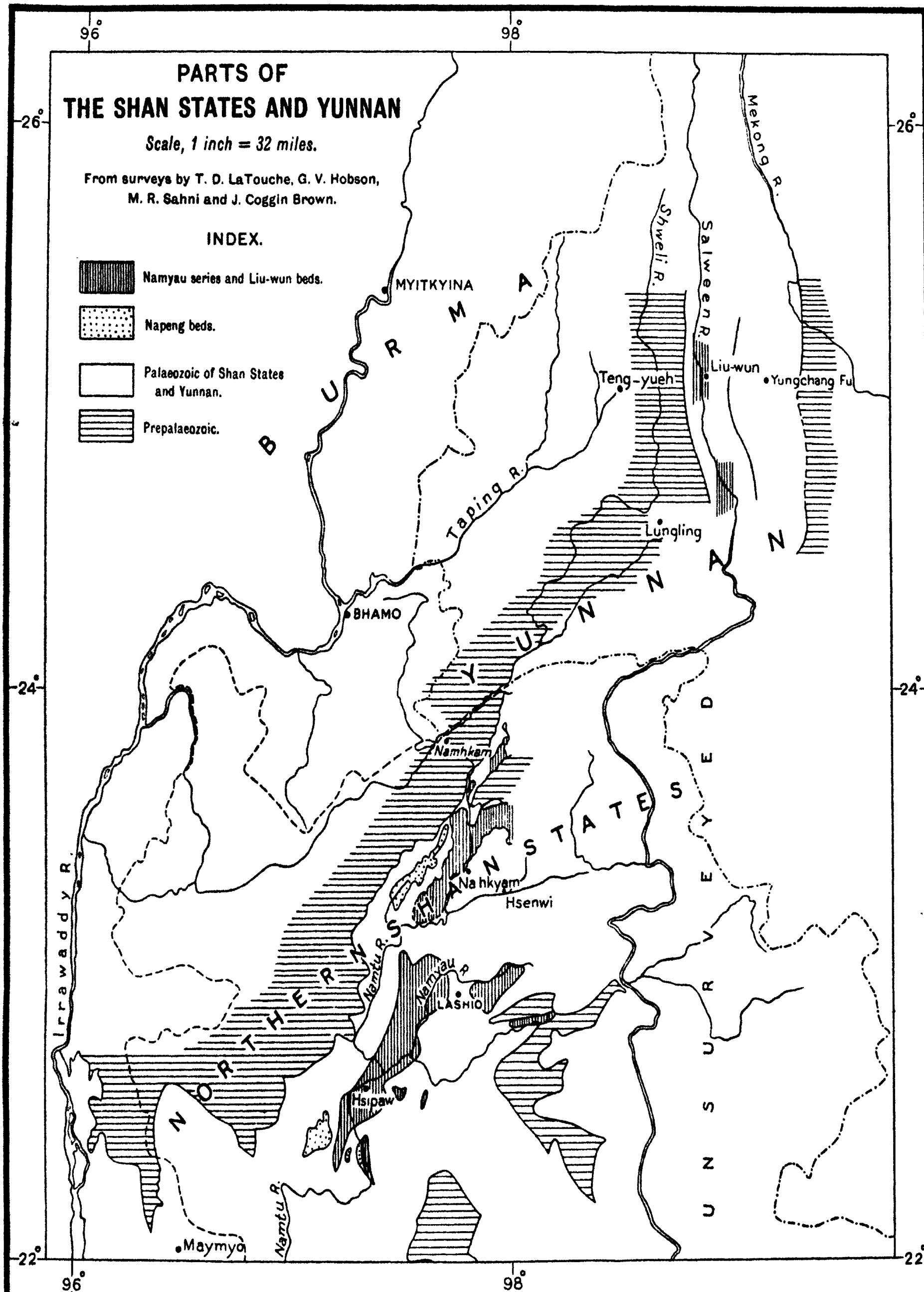
FIG. 2.

FIG. 3.

S. N. Das, Photos. *G. S. I., Calcutta.*

SPECIMEN, FORMERLY REPORTED TO BE A CEPHALOPOD, FROM RED BEDS OF KALAW.

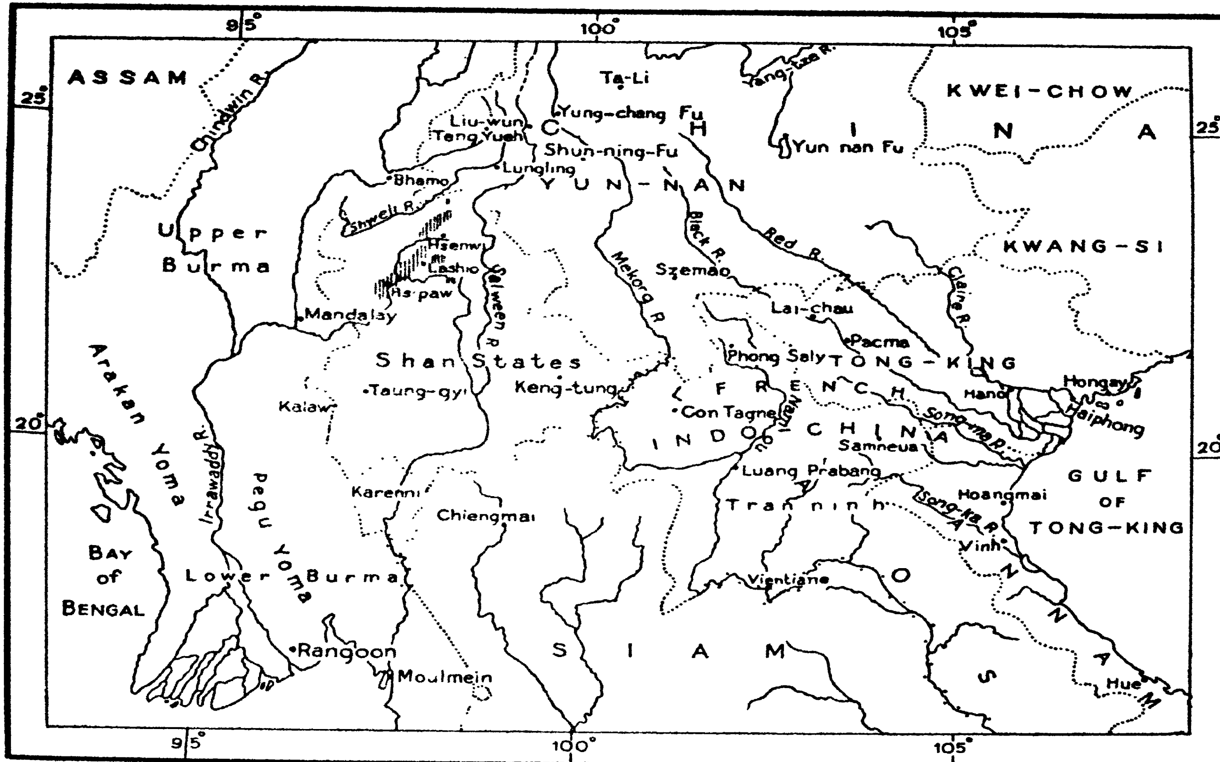
All figures are of natural size.



R. N. Sawoo, del.

G. S. I., Calcutta.

Note.—Prepalaeozoic includes Mogok and Frontier gneisses and associated crystalline rocks, Chaung Magyi series, Kaoliang series, Tawngpeng granite and other intrusives. The limits of the Liu-wun beds in Yunnan are only diagrammatic.



R. N. Sawoo, del

G. S. I., Calcutta.

Outline sketch map showing approximate localities of Brachiopod Beds in Yunnan, the Shan States and Indo-China.

(Shaded area in Shan States = Namyau series)

Scale, 1 inch = 160 miles, approx.

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 3.] 1936 [September.

THE MINERAL PRODUCTION OF INDIA DURING 1935. BY A. M. HERON, D.Sc., F.G.S., F.R.G.S., F.R.S.E., F.R.A.S.B., *Director, Geological Survey of India.*

CONTENTS.

I.—INTRODUCTION.

THE method of classification adopted in the first Review of Mineral Production published in these *Records* (Vol. XXXII, 1905), although admittedly not entirely satisfactory, is still the best that can be devised under present conditions. As the methods of collecting the returns become more precise, and the machinery employed for the purpose more efficient, the number of minerals included in Class I—for which approximately trustworthy annual returns are available—increases, and it is hoped that the minerals of Class II—for which regularly recurring and full particulars cannot be procured—will in time be reduced to a very small number. In the case of minerals still exploited chiefly by primitive Indian methods and thus forming the basis of an industry carried on by a large number of persons each working independently and on a very small scale, the collection of reliable statistics is impossible; the total error from year to year, however, is characterised by some degree of constancy, and the figures obtained may be accepted as a fairly reliable index to the general trend of the industry. In the case of gold, the small indigenous alluvial industry contributes such an insignificant portion to the total outturn that the error from this source may be regarded as negligible.

Since the figures of mineral production published in these Reviews are in many cases greater than those published in the Annual Returns of the Chief Inspector of Mines, it is desirable to explain that the figures published by the Chief Inspector of Mines are confined to mines and workings that come under the Mines Act, which relates only to British India; whereas the figures published in these Reviews include the production of both Act and non-Act workings in British India, and also the production of the Indian States. For the provision of the data we are indebted to the Chief Inspector of Mines and the Local Governments in respect of British India, and to the Indian Durbars and Political Agents in the case of Indian States.

The average value of the Indian rupee during the year 1935 was 1*s*. $6\frac{3}{32}$*d*.; the highest value reached was 1*s*. $6\frac{1}{8}$*d*. and the lowest 1*s*. $6\frac{1}{16}$*d*. The values for 1935 shown in the tables are given on the basis of 1*s*. $6\frac{3}{32}$*d*. to the rupee, for ease of calculation, £1 has been taken to be equivalent to Rs. 13·3 instead of Rs. 13·27.

Table 1 shows the total value of minerals for which returns of production are available for the years 1934 and 1935. The average figure for the quinquennium, 1919-1923, was £25,194,123. In the following year, 1924, there was an apparent increase of over £3,500,000; this was, in part, however, due to the higher average value of the rupee during that year. Since 1924, there has been a steady decline, which persisted down to the year 1928, for which the value was £21,888,528. There was an arrest in this decline in 1929, which showed an increase in total value to £22,328,686, or about 2 per cent. over that of 1928. In 1930, however, the decline was resumed and the total value of the production fell annually to £15,612,235 in 1932. In 1933, the tide turned again and the total value of the output increased by nearly £1,000,000 to £16,599,837. This rise continued in 1934 when the total value increased by £1,068,550 to £17,668,387 and in 1935, by £1,851,649 to £19,520,036. Of each of the sixteen minerals with a value of over £100,000 annually, increases are shown by manganese-ore (144·9 per cent.), zinc concentrates (41·9 per cent.), silver (36·7 per cent.), mica (33·9 per cent.), lead and lead-ore (28·2 per cent.), nickel-speiss (21·8 per cent.), iron-ore (19·4 per cent.), copper-ore and matte (9·3 per cent.), tungsten-ore (4·1 per cent.), gold and petroleum (3·8 per cent.), coal (3·1 per cent.), building materials (2·9 per cent.), salt (0·1 per cent.); decreases are shown by saltpetre and tin-ore (0·2 per cent.). Coal remains at the head of the list of values as the most important mineral, whilst manganese-ore, India's other most distressed mineral industry, continues to make a recovery. Amongst less important minerals the largest increases in value are shown by zircon, monazite, bauxite, beryl, graphite, refractory materials, antimonial lead, chromite and ilmenite: whilst the most important decreases are shown by diamond, jadeite, ruby, sapphire and spinel.

An increase or decrease in value does not always correspond to a similar variation in output, and cannot, therefore, be regarded as an infallible indication of the state of an industry. But in 1935, in all cases, with four exceptions, an increase or decrease of value accompanied an increase or decrease in the quantity of production. The exceptions were saltpetre, tin and felspar, in which increases in output were accompanied by decreases in total value; and salt in which decrease in quantity was accompanied by increase in value.

TABLE 1.—*Total Value of Minerals for which returns of Production are available for the years 1934 and 1935.*

—	1934.	1935.	Increase.	Decrease.	Variation per cent.
	£	£	£	£	
Coal	4,741,425	4,903,822	162,397	..	+3·4
Petroleum (*a*) . .	4,514,389	4,685,333	170,944	..	+3·8
Gold	2,200,836	2,285,848	85,012	..	+3·8
Lead and lead-ore (*b*) .	787,859	1,010,414	222,555	..	+28·2
Manganese-ore (*d*) .	388,240	950,630	562,390	..	+144·9
Building materials .	860,116	885,190	25,074	..	+2·9
Salt	877,720	878,882	1,162	..	+0·1
Silver . . .	562,857	769,454	206,597	..	+36·7
Tin-ore . . .	764,688	763,081	..	1,607	—0·2
Mica (*c*) . . .	453,423	604,111	150,688	..	+33·2
Copper-ore and matte .	422,537	462,031	39,494	..	+9·3
Tungsten-ore . .	284,956	296,693	11,737	..	+4·1
Zinc concentrates .	201,309	285,666	84,357	..	+41·9
Iron-ore . . .	223,443	266,942	43,499	..	+19·4
Nickel-speiss . .	86,401	105,269	18,868	..	+21·8
Saltpetre (*e*) . .	100,614	100,420	..	194	—0·2
Ilmenite . . .	(*e*) 39,245	58,789	19,544	..	+49·8
Chromite . . .	23,313	36,087	12,774	..	+54·8
Refractory materials .	13,519	30,301	16,782	..	+124·1
Clays . . .	25,806	29,591	3,785	..	+14·3
Antimonial lead . .	15,617	27,065	11,448	..	+73·3
Steatite . . .	12,800	14,403	1,603	..	+12·5
Monazite . . .	(*e*) 3,769	12,453	8,684	..	+230·4
Ruby, sapphire and spinel.	13,181	8,601	..	4,580	—34·7
Magnesite . . .	7,385	7,918	533	..	+7·5
Zircon . . .	(*e*) 1,030	6,967	5,937	..	+576·4
Gypsum . . .	6,860	6,945	85	..	+1·2
Fuller's earth . .	6,787	6,159	..	628	—9·3
Jadeite (*c*) . . .	10,967	5,678	..	5,289	—48·2
Diamonds . . .	9,211	4,201	..	5,010	—54·4
Ochres . . .	(*e*) 3,258	3,082	..	176	—5·1
Barytes . . .	2,651	2,628	..	23	—0·9
Bauxite . . .	7	1,148	1,141	..	..
Graphite . . .	359	863	504	..	+140·4
Soap sand . . .	652	763	111	..	+17·0
Beryl . . .	124	641	517	..	+417·0
Corundum . . .	..	465	465	..	..
Felspar . . .	474	372	..	102	—21·5
Antimony-ore . .	..	254	254	..	..
Garnet . . .	169	244	75	..	+44·4
Amber . . .	12	158	146	..	..
Apatite . . .	67	115	48	..	+71·6
Asbestos . . .	311	343	32	..	+10·3
Bismuth . . .	..	16	16	..	..
TOTAL .	**17,668,387**	**19,520,036**	**1,869,258**	**17,609**	**+10·5**
			+1,851,649		

(*a*) Estimated. (*b*) Excludes antimonial lead. (*c*) Export values. (*d*) Exports *f.o.b.* values. (*e*) Revised.

It is interesting to compare the changes in the figures of total value recorded in Table 1 with the variations in the average annual value of the leading metals and ores as summarised in Table 2. In 1931 all the metals and ores given in this table showed a fall in price except gold, in the price of which there was a substantial rise. In 1932 there was a very large rise in the price of gold, and in addition a partial recovery in the price of spelter, tin and silver. In 1933 there were small falls in the price of lead and chromite; the prices of steel rails, ferro-manganese and manganese-ore were stationary; whilst the prices of other metals and ores rose, the largest rise being that of tin. In 1934 there was a spectacular rise in the price of wolfram, and further substantial rises in the prices of tin, gold and silver, with a small rise in the prices of manganese-ore and pig-iron; on the other hand there were falls in the prices of copper, lead, spelter, petrol and kerosene, whilst the prices of steel rails, ferro-manganese, and chromite were stationary. In 1935 prices were much steadier, with a general upward tendency, except in the cases of tin, chromite and wolfram, which declined slightly, steel rails and ferro-manganese being stationary.

The number of mineral concessions granted during the year under review amounted to 567 against 482 in the preceding year. Of these 31 were quarry leases, 450 were prospecting licenses, and 86 were mining leases. This small total compared with the figure (714 mineral concessions) for 1927 is an index of the decreased prospecting that accompanies a period of depression. In the same way the increase in 1933 (406), 1934 and 1935 compared with 1932 (327) should be an index of the turn of the tide.

The average number of persons employed daily during 1935 was 371,522 against 334,848 in the previous year, as recorded in Table 3. It will be seen that the most important mineral industries in providing employment are, in order, coal, salt, mica, gold, tin- and tungsten-ores, petroleum, iron-ore, and manganese-ore. In addition, much additional employment is, of course, provided to the transport, smelting and refining industries.

In Part 4 of Volume LXVI of these *Records* is a paper giving tables of production, imports, exports, and of consumption of minerals and metals in India for 1913, 1917, 1920, and 1926 to 1931.

These data are given in considerable detail and similar data could not easily be obtained in full in time for incorporation in

TABLE 2.—*Average Prices in the United Kingdom of Principal Metals, Ores and Oils during the years 1934 and 1935.*

		1934.	1935
Metals—			
Copper, standard, per ton	£	30·32	31·90
Lead, pig, soft, foreign, per ton	£	11·05	14·28
Spelter, ordinary, per ton	£	13·77	14·17
Tin, standard, per ton	£	230·37	225·72
Pig iron, Cleveland No. 3, per ton	£	3·34	3·39
Steel rails, per ton	£	8·37	8·37
Ferro-manganese, per ton	£	11·25	11·25
Gold, fine, per ounce	sh.	137·646	142·119
Silver, standard, per ounce	d.	21·228	28·905
Ores—			
Chromite, 48-57 per cent., per ton	£	4·625	4·575
Manganese-ore, first grade, per unit	d.	10·5	11·2
Wolfram, per unit	sh.	37·167	34·416
Oils—			
Petrol, per gallon	d.	8·21	8·66
Kerosene, per gallon	d.	7·22	7·60

TABLE 3. *Average number of Persons Employed daily in the production of minerals from mines in India for which reliable returns of labour statistics are available.*

	1934.	1935.
Chromite	1,825	2,435
Coal	169,354	179,152
Copper-ore	2,787	2,784
Diamonds	1,798	1,138
Gold	21,652	22,444
Iron-ore	14,272	16,833
Lead ore	3,496	3,557
Magnesite	1,086	1,059
Manganese-ore	8,549	16,242
Mica	15,033	23,108
Monazite, zircon and ilmenite	2,116	3,663
Petroleum	18,389	18,281
Salt	(*a*) 60,584	60,739
Tin- and tungsten-ores	13,804	20,034
TOTAL	**334,745**	**371,469**

(*a*) Revised.

successive annual reviews of mineral production without causing undue delay. It is possible, however, to bring up to date Table V of that review showing the quantities of ores, metals and other mineral products available for consumption in India. These data for 1935 are summarised in Table 4 of this present Review.

TABLE 4.—*Consumption, 1935.*

Ores, minerals and metals. 1	Kinds and grades. 2	Unit. 3	Production. 4	Retained imports. 5	Exports of domestic production. 6	Ores, minerals and metals available for consumption. Columns 4 + 5 — 6. 7
Aluminium . .	Aluminium unwrought (ingots, blocks, etc.).	Cwts.	..	166	..	166
	Bauxite . . .	Tons	7,635	..	(a)	..
Amber . . .	....	Lbs.	2,083	..	..	2,083
Antimony . .	Antimony-ore . .	Tons	34	..	(a)	..
	Antimonial lead . .	Tons	1,500	..	(a)	..
Arsenic . . .	Arsenic and its oxides .	Cwts.	(b)	3,016	..	3,016
Asbestos . .	....	Tons	63	(c)	..	..
Barytes . .	....	Tons	5,493	1,270	..	6,763
Beryl . . .	....	Tons	139	..	(a)	..
Borates . .	Borax (including boracic acid).	Cwts.	(b)	33,895	635	33,260
Brass . . .	...	Tons	10,721	28,572	(d) 524	38,769
Clays . .	Clays other than china clay.	Tons	297,514	..	..	297,514
	China clay . . .	Tons	14,435	23,513	..	37,948
Chrome-ore . .	Chromite . . .	Tons	39,127	..	(e)41,210	..
Coal, coke and bye-products.	Bituminous non-coking coal, bituminous coking coal, anthracite.	Tons	23,016,695	76,899	217,584	22,876,010
	Coal tar and pitch .	Tons	61,984	4,457	..	66,441
	Sulphate of ammonia .	Tons	15,398	44,029	7,376	52,051

(a) Known to be exported, but export figures are not available.
(b) Known to be produced, but production figures are not available.
(c) Complete figures for quantity are not available; value Rs. 14,88,992.
(d) Includes bronze and similar alloys.
(e) Includes 15,156 tons produced in British India but exported from Mormugao in Portuguese India.

TABLE 4.—*Consumption, 1935*—contd.

Ores, minerals and metals. 1	Kinds and grades. 2	Unit. 3	Production. 4	Retained imports. 5	Exports of domestic production. 6	Ores, minerals and metals available for consumption. Columns 4 + 5 — 6. 7
Copper	Metal unwrought	Tons	6,900	1,415	..	8,315
Copper-matte	....	Tons	8,950	..	(b)9,820	..
Diamonds	....	Carats	1,401	(c)	..	1,401
Ferro-manganese	....	Tons	14,182	..	..	14,182
Ferro-alloys	....	Tons	..	3,067	..	3,067
Felspar	....	Tons	702	..	..	702
Fuller's earth	....	Tons	7,644	..	..	7,644
Garnet sand	....	Tons	325	..	(a)	..
Gold	....	Fine Ounces	327,652	107,257	(d)4,732,185	..
Graphite	....	Tons	557	545	..	1,102
Gypsum	....	Tons	45,318	..	..	45,318
Ilmenite	....	Tons	127,051	..	(a)	..
Iron	Ore	Tons	2,364,297	..	..	..
	Pig	Tons	1,451,862	1,619	472,636	980,845
	Steel	Tons	627,867	81,233	559	708,541
	Manufactures of iron or steel other than those included under 'steel.'	Tons	(e)	275,058	57,972	217,086
Jadeite	....	Cwts.	1,265	..	1,335	..
Lead	Ore	Tons	460,886	..	..	..
	Pig	Tons	70,560	110	66,262	4,408
Magnesite	....	Tons	16,984	..	4,084	12,900
Manganese-ore	....	Tons	641,483	..	864,698	..
Mica	....	Cwts.	58,754	150	141,814	..
Monazite	....	Tons	3,819	..	(a)	..
Nickel-speiss	....	Tons	4,850	..	(a)	..

Ochre . . .	....	Tons	8,190	..	..	8,190
Petroleum . .	Crude	Gals.	322,662,336	..	..	..
	Natural gas gasolene .	Gals.	9,717,087	..	..	..
	Petrol including benzene and dangerous spirit.	Gals.	90,629,458	1,651,528	3	92,280,983
	Kerosene . . .	Gals.	147,655,471	68,649,291	..	216,304,762
	Fuel oil . . .	Gals.	5,944,498	131,493,847	..	137,438,345
	Batching and lubricating oils.	Gals.	12,417,695	19,227,524	..	31,645,219
	Paraffin wax . .	Tons	(f)45,573	645	53,202	..
Phosphates . .	....	Tons	102	7,725	..	7,827
Potash minerals and chemicals including saltpetre.	Saltpetre . . .	Cwts.	(g)174.159	..	173,259	900
	Potash chemicals and manures.	Cwts.	..	165,097	..	165,097
Quicksilver . .	....	Lbs.	..	462,164	..	462,164
Refractory materials	....	Tons	(h)43,724	..	(a)	..
Salt	....	Tons	1,948,173	393,972	13	2,342,132
Silver . . .	....	Ounces	5,850.406	8,575,912	71,955,874	..
Steatite . .	....	Tons	12,596	..	..	12,596
Sulphur . .	....	Cwts.	..	500,877	..	500,877
Tin . . .	Ore	Tons	5,860	..	4,196	1,664
	Metal (unwrought) .	Cwts.	..	50,806	36,662	14,144
Tungsten . .	Ore	Tons	3,837	..	7,480	..
Zinc . . .	Concentrates . .	Tons	78,590	..	76,599	1,991
	Metal (unwrought) .	Tons	..	22,755	..	22,775
	Metal (wrought) . .	Tons	..	1,679	..	1,679
Zircon . . .	....	Tons	6,654	..	(a)	..

(*a*) Known to be exported, but export figures are not available.
(*b*) Presumably refers to copper-matte.
(*c*) Quantity not known. Value of diamonds imported in 1935 amounted to Rs. 23,38,477.
(*d*) Total exports, largely imported in previous years.
(*e*) Not available.
(*f*) One ton is assumed to be equivalent to 280 gallons.
(*g*) 173,259 cwts. exported *plus* 900 cwts. consumed in tea gardens in India.
(*h*) Includes 19,903 tons of kyanite.

II.—MINERALS OF GROUP I.

Antimony.

The production of antimonial lead obtained as a byo-product in the lead refinery at the Namtu smelter of the Burma Corporation Limited, increased from 1,255 tons valued at Rs. 2,07,703 (£15,617) in 1934 to 1,500 tons valued at Rs. 3,59,961 (£27,065) in 1935. This product contains 81·7 per cent. of lead, 17·65 per cent. of antimony, 0·21 per cent. of copper and 5·5 ozs. of silver to the ton, and is exported for further treatment.

An output of 34 tons of antimony-ore, valued at Rs. 3,385 (£254) was reported from the Amherst district, Burma. The last return was in 1930, when the output amounted to 3 tons valued at Rs. 60 (£4).

Chromite.

There was an increase of over 67 per cent. in the production of chromite in India from 21,576 tons in 1934 to 39,127 tons in 1935. This increase was from all fields. The total exports from India during the year were nearly 10,000 tons above those of the previous year, and were about 2,000 tons in excess of the production, amounting to 41,210 tons, made up of 26,054 tons from British India and 15,156 tons from Mormugao in Portuguese India, as compared with 27,306 tons and 3,950 tons respectively in the previous year. The value per ton was Rs. 12·3 as against Rs. 14·37 for both 1933 and 1934.

TABLE 5.—*Quantity and value of Chromite produced in India during the years 1934 and 1935.*

——	1934.			1935.		
	Quantity.	Value (£1 = Rs. 13·3).		Quantity.	Value (£1 = Rs. 13·3).	
	Tons	Rs.	£	Tons	Rs.	£
Baluchistan— Zhob	2,346	35,190	2,646	7,642	1,10,860	8,335
Bihar and Orissa— Singhbhum	7,010	92,237	6,935	11,397	1,26,514	9,512
Mysore State— Hassan	9,744	1,39,498	10,488	14,220	1,38,129	10,386
Mysore	2,476	43,141	3,244	5,868	1,04,462	7,854
TOTAL	21,576	*3,10,066*	*23,313*	39,127	*4,79,965*	*36,087*

Coal.

In 1931, 1932 and 1933 there was a continuous decrease in production of coal from the peak figure of 23,803,048 tons in 1930. In 1934 the direction of change was reversed and production increased by 2,268,284 tons (or 11·4 per cent.) from 19,789,163 tons in 1933 to 22,057,447 tons in 1934. In 1935 the increase continued but at a less rate, by 959,248 tons (or 4·3 per cent.), to 23,016,695 tons. This increase was shared by all provinces except Baluchistan, Hyderabad and Rajputana which showed slight decreases. The most important increases were in Bengal, the Central Provinces and Bihar and Orissa (*see* Table 6). In Bengal, Bihar and Orissa, the Jharia, Karanpura, Raniganj and Talchir fields showed increases, the rest decreases, the largest advances being shown by Jharia and Raniganj of nearly three-quarters of a million tons. In Central India, Sohagpur showed an increase and Umaria a decrease in the Central Provinces, Korea and Pench Valley showed increases and Ballarpur and Raigarh decreases. In Hyderabad State, the Singareni and Tandur fields showed decreases and Sasti an increase. In the Tertiary coalfields of Assam, Baluchistan, the Punjab and Rajputana, increases were shown by all the Punjab fields and by Makum in Assam, the others showing decreases.

As usual the output of the Tertiary fields was but a trivial proportion of the whole, the proportions being 98·22 per cent. from the Gondwana coalfields and 1·78 per cent. from the Tertiary coalfields.

A feature of the last 11 years has been the very large expansion of the output from the Central Provinces from 679,081 tons in 1924 to 2,118,677 tons in 1935. This undoubtedly accentuated the fall in output of Bihar and Orissa from 14,105,529 tons in 1924 to 11,257,984 tons in 1933, with a partial recovery to 12,630,409 tons in 1934, and 12,747,340 tons in 1935.

The variations in the statistical position of the coal industry since 1927 can be gauged to some extent by examining the stock position at the end of each year. Stocks increased continuously from 1929 to 1932. In the previous review it was recorded that during 1933 the position showed no substantial change, but that the slight reduction of stocks might be symptomatic of a tendency towards a better adjustment of production to demand. This surmise has proved to be partially correct, for during 1934 stocks

were reduced by nearly 700,000 tons, increasing by 165,529 tons in 1935. The data are given in the following table:—

Year.	Opening Stock.	Closing Stock.	Reduction during year.
	Tons	Tons	Tons
1927	2,161,806	1,721,288	440,518
1928	1,721,288	1,625,717	95,571
1929	1,625,717	844,240	781,477
1930	844,240	986,006	(a)141,766
1931	986,006	1,414,340	(a)428,334
1932	1,414,340	1,664,969	(a)250,629
1933	1,664,969	1,646,248	18,721
1934	1,646,248	949,625	696,623
1935	949,625	1,115,154	(a)165,529

(a) Increase of stocks.

The increased output of 4·3 per cent. in 1935 was accompanied by an increase of 3·3 per cent. in the total value of the coal produced in India, from Rs. 6,30,60,951 (£4,741,425) in 1934, to Rs. 6,52,20,840 (£4,903,822) in 1935.

There was a further decrease of 5 pies in the pit's mouth value per ton of coal for India as a whole, namely from Rs. 2-13-9 to Rs. 2-13-4. With three exceptions a fall was recorded in every province. In the two great coal provinces, Bihar and Orissa and Bengal, the value fell by Re. 0-0-8 and Re. 0-1-4 respectively. In other provinces, the price fell in Central India by Re. 0-1-1 ; in the Punjab by Re. 0-1-11 ; in Rajputana by Re. 0-2-10, and in the Central Provinces by Re. 0-2-0. On the other hand, the price rose in Assam by Rs. 1-12-9, in Baluchistan by Rs. 1-10-9 and in Hyderabad by Re. 0-2-9.

TABLE 6.—*Provincial production of Coal during the years 1934 and 1935.*

— —	1934.	1935.	Increase.	Decrease.
	Tons.	Tons.	Tons.	Tons.
Assam	189,527	220,737	31,210	..
Baluchistan	14,740	9,558	..	5,182
Bengal	6,159,486	6,682,752	523,266	..
Bihar and Orissa . . .	12,630,409	12,747,340	116,931	..
Central India . . .	289,381	329,369	39,988	..
Central Provinces . . .	1,842,492	2,118,677	276,185	..
Hyderabad	769,636	729,414	..	40,222
Punjab	125,266	144,423	19,157	..
Rajputana	36,510	34,425	..	2,085
TOTAL .	22,057,447	23,016,695	1,006,737	47,489

TABLE 7.—*Value of Coal produced in India during the years 1934 and 1935.*

——	1934.					1935.				
	Value (£1 = Rs. 13·3).		Value per ton.			Value (£1 = Rs. 13·3).		Value per ton.		
	Rs.	£	Rs.	A.	P.	Rs.	£	Rs.	A.	P.
Assam	14,48,174	108,509	7	9	10	20,77,926	156,235	9	6	7
Baluchistan . .	85,849	6,455	5	13	2	71,651	5,387	7	7	11
Bengal	1,64,29,424	1,285,295	2	10	8	1,72,76,463	1,298,982	2	9	4
Bihar and Orissa . .	3,42,00,225	2,571,446	2	11	4	3,39,66,354	2,553,861	2	10	8
Central India . .	10,31,595	77,564	3	9	0	11,52,135	86,627	3	7	11
Central Provinces . .	67,72,358	509,199	3	10	10	75,22,526	565,604	3	8	10
Hyderabad (*a*) . .	23,69,076	178,127	3	1	3	23,71,781	178,329	3	4	0
Punjab	5,62,397	42,285	4	7	10	6,30,794	47,428	4	5	11
Rajputana . . .	1,66,858	12,545	4	9	1	1,51,210	11,369	4	6	3
TOTAL .	6,30,60,951	4,741,425				6,52,20,840	4,903,822			
Average .	..	..	*2*	*13*	*9*	..	..	*2*	*13*	*4*

(*a*) Estimated.

TABLE 8.—*Origin of Indian Coal raised during the years 1934 and 1935.*

——	Average of last five years.	1934.	1935.
	Tons.	Tons.	Tons.
Gondwana coalfields	21,127,285	21,691,404	22,607,552
Tertiary coalfields	376,611	366,043	409,143
TOTAL .	**21,503,896**	**22,057,447**	**23,016,695**

TABLE 9.—*Output of Gondwana Coalfields during the years 1934 and 1935.*

——	1934.		1935.	
	Tons.	Per cent. of Indian total.	Tons.	Per cent. of Indian total.
Bengal, Bihar and Orissa				
Bokaro	1,399,261	6·34	1,331,272	5·78
Giridih	761,010	3·45	708,789	3·08
Jainti	42,717	0 19	34,037	0·15
Jharia	9,057,546	41·06	9,245,292	40·17
Karanpura	397,147	1 80	424,536	1·84
Rajmahal Hills . . .	1,599	0·01	1,230	0·01
Rampur (Raigarh-Hingir) .	28,128	0·13	27,331	0·12
Raniganj	6,795,838	30·81	7,348,323	31 93
Talcher	306,649	1·39	309,282	1·34
Central India—				
Sohagpur	194,638	0·88	244,053	1·06
Umaria	94,743	0·43	85,316	0·37
Central Provinces—				
Ballarpur	321,038	1·46	312,591	1·36
Korea	400,350	1·82	589,806	2·56
Pench Valley	1,117,942	5·07	1,214,009	5·27
Raigarh State	3,162	0·01	2,181	0·01
Hyderabad—				
Sasti	41,880	0·19	50,545	0·22
Singareni	527,989	2·39	513,259	2·23
Tandur	199,767	0·91	165,610	0·72
TOTAL .	**21,691,404**	*98·34*	**22,607,552**	*98·22*

TABLE 10.—*Output of Tertiary Coalfields during the years 1934 and 1935.*

—	1934. Tons.	1934. Per cent. of Indian total.	1935. Tons.	1935. Per cent. of Indian total.
Assam—				
Khasi and Jaintia Hills .	3,214		2,984	
Makum	161,622	0·86	196,677	0·96
Naga Hill . . .	21,691		21,076	
Baluchistan—				
Khost	4,161	0·07	3,223	0·04
Sor Range, Mach, Kalat .	10,579		6,335	
Punjab—				
Jhelum	51,909		61,843	
Mianwali	64,985	0·57	77,073	0·63
Shahpur . . .	5,371		5,507	
Rajputana—				
Bikaner . . .	36,510	0·16	34,425	0·15
TOTAL .	**366,043**	*1·66*	**409,143**	*1·78*

The development of an iron and steel industry in India on modern lines has led to the erection of several plants for the manufacture of hard coke of metallurgical quality and it has therefore become a matter of general interest to know the proportion of the total annual output of coal in India that is utilised in the manufacture of hard coke. The figures for 1934 and 1935 are shown in Table 11. The substantial increase in the production of hard coke in 1935 is a concomitant of the greatly increased activity of the Indian iron and steel industry.

TABLE 11.—*Quantity of Hard Coke produced in India during the years 1934 and 1935.*

—	1934.	1935.
	Tons.	Tons.
Coal used	2,043,967	2,353,441
Hard coke manufactured	1,517,137	1,766,821
Percentage recovery	*74·23*	*75·07*
Sources of coal used—		
Jharia field	1,934,048	2,232,807
Giridih field	26,297	26,740
Raniganj field	80,924	91,035
Lakhimpur (Namdang) field	2,698	2,859
TOTAL	2,043,967	2,353,441
Coal used for coking by—		
Three iron and steel companies	1,701,227	1,912,036
Others	342,740	441,405

In continuation of the trend of 1934, the export statistics for coal during 1935 show a further decrease amounting to about 112,000 tons (*see* Table 12). Ceylon retained her position as the leading importer of Indian coal, though she took 82,000 tons less than in 1934. The Straits Settlements showed a decrease of 18,000 tons, and Hongkong of 10,000 tons. The export of coke decreased by 737 tons.

TABLE 12.—*Exports to Foreign Countries of Indian Coal and Coke during the years 1934 and 1935.*

—	1934.			1935.		
	Quantity.	Value (£1 = Rs. 13·3).		Quantity.	Value (£1 = Rs. 13·3).	
	Tons.	Rs.	£	Tons.	Rs.	£
To— Ceylon	228,040	25,48,999	191,654	145,914	13,65,042	102,635
Hongkong	55,893	3,35,358	25,215	45,830	3,11,346	23,409
Straits Settlements	34,922	2,33,237	17,537	16,642	1,00,400	7,549
United Kingdom	18	95	7	..	..	..
Other countries	8,917	78,351	5,891	7,492	61,626	4,634
TOTAL	327,790	31,96,040	240,304	215,878	18,38,414	138,227
Coke	2,443	42,017	3,159	1,706	23,924	1,799
Total of Coal and Coke	330,233	32,38,057	243,463	217,584	18,62,338	140,026

The following table gives the amounts of different grades of coal exported during 1934 and 1935 under the Indian Coal Grading Board's scheme (including sea-borne coal for railways in Southern India, for which no grade shipment certificates were issued by the Coal Grading Board) and shows an increase of 77,026 tons in the present year, the difference between the total amounts so exported (1,885,262 tons in 1935) and the total exports of Indian coal to foreign ports given in Table 12 (215,878 tons in 1935) being the amount of coal exported to Indian ports.

TABLE 13.—*Exports of Coal under Grading Board Certificates during the years 1934 and 1935.*

—	1934.	1935.
	Tons.	Tons.
Selected grade	1,665,377	1,783,023
Grade I	142,859	94,467
Grade II	..	3,302
Mixed grade	..	4,470
TOTAL	1,808,236	1,885,262

In reversal of the trend of previous years, imports of coal and coke showed increases during 1932 and 1933, namely from 47,544 tons in 1932 to 67,330 in 1933, 21,121 tons of the latter consisted of coke. 1934 showed a further slight increase to 72,161 tons, of which 14,719 tons were coke, and 1935 an increase to 77,075 tons, of which 12,791 tons were coke (*see* Table 14). This latter rise is due mainly to an increase of some 12,000 tons from "other countries", partially offset by a decrease of 4,357 tons from Australia and a decrease of some 2,000 tons in the amount of coke imported. The total imports are now about a sixth of those of the pre-war quinquennium and Table 15, comparing pre-war imports and exports with the figures from 1926 to 1935, shows that the depression in the Indian coal industry, which reached its maximum in 1933, cannot be ascribed to the competitive effect of foreign imported coal. The average surplus of exports during the years 1926 to 1935 was, in fact, slightly greater than the surplus during the pre-war quinquennium, but the inequality seems to be disappearing.

The true cause of the depression in the Indian coal industry is over-development of the coalfields with reference to India's requirements. Every new coalfield that is opened up at present merely serves to accentuate the depression.

TABLE 14.—*Imports of Coal and Coke during the years 1934 and 1935.*

—	1934.			1935.		
	Quantity.	Value (£1 = Rs. 13·3).		Quantity.	Value (£1 = Rs. 13·3).	
	Tons.	Rs.	£	Tons.	Rs.	£
From—						
Australia . . .	6,981	1,41,302	10,624	2,624	45,008	3,384
United Kingdom	11,415	2,18,930	16,461	11,403	2,30,024	17,295
Union of South Africa	33,003	4,75,867	35,779	32,145	4,66,878	35,103
Other countries . .	6,043	1,00,216	7,535	18,112	2,62,306	19,722
TOTAL .	57,442	9,36,315	70,399	64,284	10,04,211	75,504
Coke	14,719	3,44,626	25,912	12,791	3,03,146	22,793
Total of Coal and Coke .	**72,161**	12,80,941	96,311	**77,075**	**13,07,357**	**98,297**

TABLE 15.—*Excess of exports over imports of Coal.*

——	Exports.	Imports.	Excess of exports over imports.
	Tons.	Tons.	Tons.
Average for 1909-13	814,475	466,162	348,313
1926	617,563	193,908	423,655
1927	576,167	243,603	332,564
1928	626,343	210,186	416,157
1929	726,610	218,560	508,050
1930	461,188	217,029	244,159
1931	441,249	88,035	353,214
1932	519,483	47,544	471,939
1933	426,176	67,330	358,846
1934	330,233	72,161	258,072
1935	217,584	77,075	140,509

The average number of persons employed in the coalfields during the year showed a greater increase (5·8 per cent.) than the increase in production (4·3 per cent.). The average output per person employed, therefore, showed a decrease from the high figure of 130·2 tons in 1934, which is practically the same as the figure for 1929, namely 130·4 tons, the highest figure recorded, to 128·5 tons in 1935. All the figures for the last seven years are higher than those previously recorded; these higher figures are due partly to an increased use of mechanical coal-cutters, and partly to concentration of work. During recent years a large number of collieries have been shut down and the labour absorbed in the remainder; this concentration permits of a proportional reduction of the supervising staff, resulting in a larger tonnage per head. There was an increase in the number of deaths by accident from 169 in 1934 to 274 in 1935, which was chiefly due to the three major accidents at Loyabad and Bagdigi collieries in the Jharia coalfield and at Kurhurbaree colliery in the Giridih coalfield, in which 11, 19 and 62 lives, respectively, were lost. These figures are the same as the

annual average for the quinquennium 1919-1923, which was 274, and may be compared with the annual average for the quinquennium 1924-1928, which was 218, and the annual average for 1929-1933, which was 186. The death rate was 1·53 per thousand persons employed in 1935 against 1·00 for the previous year; the average figure for the period 1919-1923 was 1·36, for the period 1924-1928 was 1·16, and for the period 1929-1933 was 1·08.

TABLE 16.—*Average number of persons employed daily in the Indian Coalfields during the years 1934 and 1935.*

—	1934.	1935.	Output per person employed, in tons.	Number of deaths by accident.	Death rate per 1,000 persons employed.
Assam	1,695	1,828	120·7	3	1·64
Baluchistan	274	227	42·1	..	..
Bengal	44,619	49,913	133·9	48	0·96
Bihar and Orissa	93,163	94,873	134·4	185	1·95
Central India	2,378	2,540	129·7	4	1·57
Central Provinces	15,872	17,133	123·7	22	1·28
Hyderabad	9,471	10,626	68·6	6	0·56
Punjab	1,790	1,861	77·6	6	3·22
Rajputana	92	151	228·0	..	..
TOTAL	169,354	179,152	..	274	..
Average	..	..	*128·5*	..	*1·53*

Cobalt (*see* Nickel).

Copper.

The progress of work at the Mosaboni Mine of the Indian Copper Corporation, Ltd., in the Singhbhum district, and on the milling

and smelting plant at Maubhandar, near Ghatsila, Bengal Nagpur Railway, has been noticed in previous Reviews. Operations commenced on a revenue basis on January 1st, 1929, and the progress of the industry until 1933 is summarised in the Quinquennial Review for 1929-1933. They show that in spite of falling prices the production of both mine and smelter has continued to expand. In addition, from 1933 onwards, there has been production of ore from Dhobani, where a lode parallel to that at Mosaboni is being opened up. During 1935 the mine output increased to 349,215 long tons of copper-ore from Mosaboni and 1,586 long tons from Dhobani, making a total of 350,801 long tons, valued at Rs. 34,88,808 (£262,316), against 328,676 long tons of copper-ore in 1934 valued at Rs. 34,19,869 (£257,133). A total of 334,589 short tons of ore was treated in the mill, and the production of refined copper amounted to 6,900 long tons against 6,300 tons in the previous year. A total of 6,734 tons of copper ingots was consumed in the rolling mill and 469 tons were sold in the Indian market at an average price of Rs. 630 per ton. Operations in the rolling mill resulted in the production of 9,843 long tons of yellow metal sheet and 878 long tons of yellow metal circles, the whole of which was sold in India at average prices of Rs. 590 and Rs. 643 respectively per long ton.

The total ore réserves at the close of the year 1935 amounted to 950,801 short tons with an average assay value of 3·19 per cent. of copper against 932,143 short tons with an average assay value of 3·10 per cent. of copper at the end of 1934. The Indian Copper Corporation reached the dividend paying stage in 1933.

There was a decrease in the production of copper matte at the Namtu smelting plant of the Burma Corporation, Limited, from 11,000 tons valued at Rs. 21,99,879 (£165,404) in 1934, to 8,950 tons valued at Rs. 26,56,205 (£199,715) in 1935 and averaging 41·77 per cent. of copper, 26·50 per cent. of lead and 93·34 ozs. of silver to the ton.

In 1932, 365 tons of copper-ore, valued at Rs. 6,900 (£519), were produced in the Nellore district, Madras. There was no recorded production in 1933, 1934 and 1935.

Diamonds.

The production of diamonds in Central India fell from 2,480 carats valued at Rs. 1,22,501 (£9,211) in 1934, to 1,401 carats valued

at Rs. 55,877 (£4,201) in 1935. Of this latter production 1,306 carats were produced in Panna State and the remainder in Charkhari and Ajaigarh States.

Gold.

In 1931 the gradual secular decline in the total Indian gold production was temporarily arrested with an output of 330,488·8 ozs. valued at Rs. 2,08,01,943 (£1,540,885), followed by a trivial fall again in 1932, when the output was 329,681·7 ozs. valued at Rs. 2,53,51,438 (£1,906,123). In 1933 there was an increase to 336,108·3 ozs. valued at Rs. 2,76,40,071 (£2,078,201). In 1934 the output fell to 322,142·9 ozs., but the value increased to Rs. 2,92,71,130 (£2,200,836), being the highest in terms of sterling since 1920. It is interesting to note that the output of 1921, which was valued at £2,050,575 a figure very close to that of the 1933 production, was 432,722·6 ozs. In 1935 the output rose again to 327,652·5 ozs. valued at Rs. 3,04,01,775 (£2,285,848).

There was again a small production from Manbhum but not from Singhbhum, and trivial outputs from the Punjab and the United Provinces. The Burma output increased from 889·9 ozs. in 1934 to 1,482·5 ozs. in 1935, including 1,222 ozs. from the operations of the Burma Corporation in the Northern Shan States. But these figures, are, of course, quite insignificant compared with the output of Kolar, which makes up 99·5 per cent. of the Indian total. The considerable increase in the value of the production in 1932 was due to that being the first full year since Britain and India abandoned the gold standard in September, 1931, with consequent appreciation in the price of gold against sterling or rupees. As a result of this appreciation, 9,766,122 ozs. of gold reckoned in terms of fine gold were exported during 1932. The value was Rs. 75,87,52,203 (£57,049,038). In 1933 the exports were 6,248,095 ozs. valued at Rs. 51,25,48,810 (£38,537,505), in 1934 they were 6,685,900 ozs. valued at Rs. 60,50,74,489 (£45,494,323), and in 1935, 4,732,185 ozs. valued at Rs. 44,22,27,875 (£33,250,216).

Of the four mines that were producing gold in the Kolar Gold Field, the Champion Reef and the Ooregum Mines, the two deepest on the field, reached vertical depths of 7,811 feet and 7,661 feet respectively below field datum (2,967·21 feet above Madras sea-level) on the 31st December, 1934. The development in depth has disclosed the continuity of the reef, and a number of shoots of

payable ore have been opened up. At these depths the dip of the reef is almost vertical. The ore is not refractory and yields its gold to blanket concentration and cyaniding; 'all-sliming' practice is becoming general. The concentrates are pan- or plate-amalgamated. The rock temperature at the deepest working place is over 130°F. Owing to the great depths of these mines and the consequent high temperatures, the maintenance of adequate ventilation at the working places is an extremely complex problem, and it has been partly solved by sinking deep smooth-lined vertical shafts, circular or elliptical, and by an extensive use of large electrically-driven fans in the course of the main air currents. The subsidiary shafts and winzes in the lower levels are brick- or concrete-lined and as such assist the free movement of air by reducing friction to a minimum. Though rockbursts cannot be eliminated altogether in deep mining, the more rigid forms of support, such as packs of masonry and concrete and sand or waste rock filling, which are generally used in these mines, have resulted in the reduction of the number of heavier rockbursts which were causing considerable damage to person and property in the past.

The average number of persons employed on the Kolar Gold Field during 1935 was 22,271, of whom 14,120 worked underground.

TABLE 17.—*Quantity and value of Gold*[1] *produced in India during the years 1934 and 1935.*

	1934.			1935			Labour in 1935.
	Quantity	Value (£1 = Rs. 13·3).		Quantity	Value (£1 = Rs. 13·3)		
	Ozs.	Rs.	£	Ozs.	Rs.	£	
Bihar and Orissa—							
Manbhum .	51·0	3,913	294	33·0	2,906	218	26
Singhbhum .	63·0	4,410	332	.		.	8
Burma—							
Katha . .	103·7	5,971	449	72·1	5,235	394	5
Upper Chindwin	42·2	4,508	339	188·1	20,862	1,569	..
Northern Shan States.	744·0	52,778	3,968	1,222·0	89,449	6,726	.
Mysore . .	321,188·2	2,91,99,075	2,195,419	326,124·5	3,02,82,269	2,276,862	22,271
Punjab . .	0·9	85	6	10·0	882	66	91
United Provinces	4·9	890	29	2·5	172	13	43
TOTAL .	322,142·9	*2,92,71,130*	*2,200,836*	327,652·5	*3,04,01,775*	*2,285,848*	*22,444*

[1]Fine ounces in the case of Mysore.

Ilmenite.

There was a large increase in the production of ilmenite in Travancore State from 75,644 tons valued at £39,245[1] in 1934 to 127,051 tons valued at £58,789 in 1935, this being the highest output yet recorded. Since 1927 India has been the world's largest producer of ilmenite. This mineral occurs in the monazite sands and, up to a few years ago, was looked upon as a by-product of the monazite industry. The monazite sands have been worked continuously since 1911, but it was not until 1922 that the export of ilmenite commenced, since when the production of the mineral has expanded almost continuously, so that in both quantity and value the production of ilmenite is now much more important than that of the associated minerals monazite and zircon. This steady increase in the output of ilmenite is due to the demand for its content of titanium dioxide in the manufacture of titanium paints.

Iron.

For some years up to and including 1929 the production of iron-ore in India had been steadily increasing; India is now, in fact, the second largest producer in the British Empire, and yields place only to the United Kingdom. Her output is of course still completely dwarfed by the production in the United States (17½ million tons in 1933 and nearly 25 million tons in 1934) and France (30 and 32 million tons in 1933 and 1934 respectively); but her reserves of ore are not much less than three-quarters of the estimated total in the United States and there is every hope that India will eventually take a much more important place among the world's producers of iron-ore. From 2,430,136 tons in 1929 the output of iron-ore in India fell to 1,228,625 tons in 1933. In 1934, however, there was a turn of the tide and the production recovered sharply to 1,916,918 tons, and in 1935 rose still further to 2,364,297 tons. As will be seen later, there were also substantial increases in the output of pig-iron and steel. The figures shown against the Keonjhar and Mayurbhanj States in Table 18 represent the production by Bird & Co., and the Tata Iron and Steel Co., Ltd., respectively. Of the total production of 1,155,965 tons shown against Singhbhum, 526,022 tons were produced by the Tata Iron

[1] Revised value.

and Steel Co., Ltd., from their Noamundi mine, 422,801 tons by the Indian Iron and Steel Co., Ltd., from their mines at Gua, 205,855 tons by the Bengal Iron Co., from their mines at Pansira, Ajita and Maclellan, and 1,287 tons by others. The output of iron-ore in Burma is by the Burma Corporation, Limited, and is used as a flux in lead smelting.

TABLE 18.—*Quantity and value of Iron-ore produced in India during the years 1934 and 1935.*

—	1934.			1935.		
	Quantity.	Value (£1 = Rs. 13·3).		Quantity.	Value (£1 = Rs. 13·3).	
	Tons	Rs.	£	Tons	Rs.	£
Bihar and Orissa—						
Keonjhar State . . .	397,461	3,97,461	29,884	283,489	2,83,488	21,315
Mayurbhanj State . .	645,108	9,98,517	75,076	876,939	12,85,740	96,672
Singhbhum . . .	810,547	13,32,381	100,179	1,155,965	18,09,413	136,046
Burma—						
Northern Shan States. .	23,930	(*a*)95,720	7,197	23,085	(*a*)92,340	6,943
Central Provinces . . .	898	2,694	203	800	2,400	180
Mysore State. . .	38,974	1,45,026	10,904	24,019	76,946	5,786
TOTAL .	**1,916,918**	*29,71,799*	*223,443*	**2,364,297**	*35,50,327*	*266,942*

(*a*) Estimated.

As with the preceding year there was a rise in the total output of iron and steel by the Tata Iron and Steel Co. at Jamshedpur. The production of pig-iron rose from 882,054 tons in 1934 to 897,976 tons in 1935, with increases in the production of steel (including steel rails) from 596,981 tons in 1934 to 627,867 tons in 1935. There was an increase in the production of ferro-manganese from 5,536 tons in 1934 to 14,182 tons in 1935. There was a revived production of pig-iron by the Bengal Iron Co. of 125,850 tons; their output of products made from pig-iron in 1935 amounted to 27,791 tons of sleepers and chairs, and 17,816 tons of pipes and other castings, against 22,745 tons and 21,308 tons, respectively, in 1934. The Indian Iron and Steel Co. decreased their production of pig-iron from 420,271 tons in 1934 to 408,884 tons in 1935. The output of pig-iron by the Mysore Iron Works rose slightly from 17,885 tons in 1934 to 19,152 tons in 1935. The total production of

pig-iron in India rose from 1,320,210 tons in 1934 to 1,451,862 tons in 1935, and is shown in Table 19.

TABLE 19.—*Production of Pig-iron in India during the years 1934 and 1935.*

-- —	1934.	1935.
	Tons	Tons
The Tata Iron and Steel Company, Limited . .	882,054	897,976
The Indian Iron and Steel Company, Limited . .	420,271	408,884
The Bengal Iron Company, Limited . . .	..	125,850
The Mysore Iron Works.	17,885	19,152
TOTAL .	1,320,210	1,451,862

The total number of indigenous furnaces that were at work in the Central Provinces during the year 1935 for the purpose of smelting iron-ore was 127 against 120 in the previous year; 46 furnaces were operating in the Bilaspur district, 52 in Mandla, 22 in Raipur, 2 in Chanda, 5 in Drug and none in Jubbulpore and Saugor.

The increase in the production of pig-iron in India recorded above was accompanied by a moderate rise in the quantity exported from 398,054 tons in 1934 to 472,636 tons in 1935. Table 20 shows that Japan is the principal consumer of Indian pig-iron; the proportion taken rose from 53·3 per cent. in 1934 to 70·8 per cent. in 1935, whilst the actual amount rose by 57·5 per cent. There were large decreases in exports to the United Kingdom, China and Germany, partly counterbalanced by increases to the United States and Hongkong. The export value per ton of pig-iron rose from Rs. 22·2 (£1·69) in 1934 to Rs. 23 (£1·72) in 1935.

The Steel Industry (Protection) Act, 1924 (Act No. XIV of 1924) authorised, to companies employing Indians, bounties upon rails and fishplates wholly manufactured in British India from material wholly or mainly produced from Indian iron-ore and complying with specifications approved by the Railway Board, and upon iron or steel railway wagons, a substantial portion of the component parts of which had been manufactured in British India. This Act was repealed by the Act No. III of 1927 and the payment of bounties consequently ceased on the 31st March, 1927; the industry is, however, protected to a certain extent by the varying tariffs on different classes of imported steel. As a result of a new

Act, No. XXXI of 1934, provision has been made for an increase of tariffs by about half over the 1927 rates, or about Rs. 10 per ton *ad valorem* in most cases, or about Rs. 40 per ton in the case of articles not of British manufacture.

TABLE 20.—*Exports of Pig-iron from India during the years 1934 and 1935.*

—	1934.			1935.		
	Quantity.	Value (£1 = Rs. 13 3).		Quantity.	Value (£1 = Rs. 13 3).	
	Tons	Rs.	£	Tons	Rs.	£
To—						
China . . .	19,971	4,40,199	33,098	11,366	2,64,773	19,908
Germany . . .	5,982	1,44,580	10,871	307	7,658	576
Japan . . .	212,285	46,88,284	352,502	334,267	76,61,135	576,025
Hongkong. . . .	1,711	47,088	3,540	2,401	65,641	4,935
United Kingdom . .	106,867	23,16,337	174,161	69,120	15,57,326	117,092
United States of America .	32,187	7,44,767	55,097	41,473	9,57,436	71,988
Other countries . .	19,051	4,69,147	35,207	13,612	3,30,908	25,557
TOTAL	398,054	*88,50,702*	*665,466*	472,636	*1,08,53,877*	*816,081*

Jadeite.

There was a decrease in the output of jadeite, which fell from 2,093·8 cwts. valued at Rs. 1,66,266 (£12,501) in 1934 to 1,265 cwts., with a rise in value to Rs. 1,93,149 (£14,522), however, in 1935. The output figures are liable to be incomplete, and a more correct idea of the extent of the Burmese jadeite industry, especially of values, is sometimes obtainable from the export figures. Exports by sea fell from 2,197 cwts. valued at Rs. 1,45,858 (£10,967) in 1934 to 1,154 cwts., valued at Rs. 75,512 (£5,678) in 1935. These shipments were entirely from Burma. Exports from Burma by land during the year amounted to 181 cwts. only.

Lead.

The production of lead-ore at the Burma Corporation's Bawdwin mines in Burma rose slightly from 443,489 tons in 1934 to 460,886 tons in 1935, whilst the total amount of metal extracted rose slightly

from 71,815 tons (including 1,255 tons of antimonial lead) valued at Rs. 1,06,86,230 (£803,476) in 1934 to 72,060 tons (including 1,500 tons of antimonial lead) valued at Rs. 1,37,98,466 (£1,037,479) in 1935. The quantity of silver extracted from the Bawdwin ores rose slightly from 5,792,019 ozs. valued at Rs. 74,44,482 (£559,736) in 1934 to 5,825,913 ozs., valued at Rs. 1,01,94,765 (£766,524) in 1935. The value of the lead per ton rose from Rs. 148·8 (£11·19) to Rs. 191·5 (£14·39) whilst the value of the silver per ounce rose from Rs. 1-4-7 (23·19*d.*) to Rs. 1-12-0 (31·6*d.*) in the year under review. The ore reserves in the Bawdwin mine as calculated on the 1st of July, 1935, totalled 3,965,199 tons, against 4,062,511 tons at the end of June, 1934, with an average composition of 24·2 per cent. of lead, 15·1 per cent. of zinc, 0·87 per cent. of copper, and 18·7 ozs. of silver per ton of lead. Included in this reserve are approximately 250,000 tons of copper-ore.

Magnesite.

The output of magnesite showed an increase of 2,009 tons, with an increase in value of Rs. 7,092 (£533). The increase was equally divided between Mysore State and the Salem district, Madras.

TABLE 21.—*Quantity and value of Magnesite produced in India during the years 1934 and 1935.*

	1934.			1935.		
	Quantity.	Value (£1=Rs. 13·3).		Quantity.	Value (£1=Rs. 13·3).	
	Tons	Rs.	£	Tons	Rs.	£
Madras—						
Salem . .	11,859	71,208	5,354	12,840	75,905	5,707
Mysore State .	3,116	27,010	2,031	4,144	29,405	2,211
TOTAL .	**14,975**	*98,218*	*7,385*	**16,984**	*1,05,310*	*7,918*

Manganese.

The catastrophic fall in the production of manganese-ore in India from the peak figures of 1927, namely 1,129,353 tons valued at £2,703,068 *f.o.b.* Indian ports to 212,604 tons with a value of

£140,022 in 1932 has been recorded in previous Reviews. In 1933 the output rose slightly to 218,307 tons but the value fell to £123,171. These are the smallest quantities and values reported since 1901, when the output was 120,891 tons valued at £122,831. In 1905 the output was 247,427 tons valued at £223,432, since when the smallest production was 450,416 tons in 1915 valued at £929,546; whilst the smallest value was in 1909 when a production of 644,660 tons was valued at £603,908. In 1934 there was, however, a partial recovery to 406,306 tons valued at £388,240, further increased in 1935 to 641,483 tons valued at £950,630. The full magnitude of this catastrophe to the Indian manganese industry is perhaps best realised from the fact that whilst the quantity of the production in 1933 was a little over one-fifth of that of the peak year of 1927, the value was less than one-twenty-second part of the value of the 1927 production. In fact in none of the major Indian mineral industries have the effects of the slump been so seriously felt as in the manganese industry; it is gratifying, therefore, that some measure of recovery can now be recorded, though the industry is still a long way from a full restoration of prosperity.

The substantial recovery in 1935 is due mainly to increases in the Balaghat (105,484 tons), Nagpur (68,775 tons) and Bhandara (24,895 tons) districts of the Central Provinces, and to Sandur State (32,080 tons) and the resumption of work in Panch Mahals. The most pleasing feature of this improvement is the recovery of the Central Provinces production from the trivial figure to which it had fallen in 1933 (28,789 tons) to 385,179 tons in 1935. During 1932 and 1933 the majority of mines in the Central Provinces had been closed, including several mines that had never been closed since the commencement of work in 1900 and 1901; there had been a total cessation of production in the Nagpur district and almost total cessation in Bhandara. The amount of ground still to be recovered can be judged from the fact that the production of the Central Provinces averaged 660,559 tons annually during the quinquennium 1924 to 1928.

The fall in the Indian output of manganese-ore of recent years can be correlated with the fall in the price of first-grade ore, *c.i.f.* United Kingdom ports, from an average of 22·9*d.* per unit in 1924 to 14·9*d.* per unit in 1929, and then to 9·5*d.* per unit in 1932 and 1933, whilst the partial recovery in output in 1934 accompanied a rise in the average price to 10·5*d.* per unit, and to 11·2*d.* in 1935.

This continued fall in the price of manganese-ore from 1924 to 1932 is to be correlated with the fact that from 1924 to 1927 the rate of increase of the world's production of manganese-ore was much greater than the rate of increase in the world's production of pig-iron and steel. And although there was a fall in the world's output of manganese-ore in 1928, there was a very large increase in 1929, greater than was justified by the increased production of iron and steel in that year, and it is evident that the world's available supplies of manganese-ore are now much in excess of normal requirements. Russia is able to place large quantities of ore on the market at a price with which many Indian producers cannot compete without a return to pre-war railway freights. The Indian trade has accordingly suffered disastrously. The Gold Coast has also become a serious competitor of recent years. The large deposits of high-grade manganese-ore discovered near Postmasburg in South Africa are also being developed, and it may be anticipated that eventually South Africa will secure a substantial portion of the world's market. Production from this field was suspended during 1932, but was resumed in May, 1933, the South African production being 20,894 tons in 1933 and 64,448 tons in 1934. With this increasing competition and falling prices it is not surprising, therefore, that in spite of the apparent prosperity of the Indian manganese industry in 1929 and 1930, as judged from figures of production and export, yet by 1930 the industry as a whole had arrived at a stage of relative depression, causing many operators to cease work. Added to increased available supplies there was in 1931 and 1932 the disastrous decline in the activities of the iron and steel industry of the world, illustrated by a decline from the peak figure of 122 million tons of steel in 1929 to about 68 million tons in 1931 and only 50 million tons in 1932. In 1933 there was partial revival and the output of steel was some 67 million tons rising to about 80 million tons in 1934 and 98 million tons in 1935. This partial recovery in the steel industry resulted in the hardening in the price of manganese-ore in 1934 and 1935 recorded in the preceding paragraph.

The present chief sources of production of manganese-ore are India, Russia, the Gold Coast, South Africa, Cuba and Brazil, whilst substantial supplies of ore are forthcoming from Japan and Czechoslovakia.

There is a steady consumption of manganese-ore at the works of the three principal Indian iron and steel companies, not only

for use in the steel furnaces of the Tata Iron and Steel Company, and for the manufacture of ferro-manganese, but also for addition to the blast furnace charge in the manufacture of pig-iron. The consumption of manganese-ore by the Indian iron and steel industry in the year under review amounted to 67,442 tons, against 43,294 tons in 1934.

TABLE 22.—*Quantity and value of Manganese-ore produced in India during the years 1934 and 1935*

	1934.		1935.	
———	Quantity.	Value f.o.b. at Indian ports.	Quantity.	Value f.o.b. at Indian ports.
Bihar and Orissa—	Tons.	£	Tons.	£
Bonai State	3,032	2,255	4,438	4,882
Keonjhar State	54,208	38,256	53,891	59,280
Singhbhum	15,112	18,890	16,667	27,153
Bombay—				
Panch Mahals	..	..	4,866	7,927
Central Provinces—				
Balaghat	131,248	175,544	236,732	403,431
Bhandara	51,949	69,482	76,844	130,955
Nagpur	2,828	3,783	71,603	122,918
Madras—				
Bellary	..	..	250	275
Sandur State	127,356	67,658	159,436	175,379
Vizagapatam	20,145	12,129	15,885	17,473
Mysore—				
Chitaldrug	81	16	377	414
Shimoga	347	197	444	488
Tumkur	..	..	50	55
TOTAL	**406,306**	*388,240*	**641,483**	*950,630*

The partial recovery of the Indian manganese industry during 1934 and 1935 was reflected in an increase of exports, including the quantities exported from Mormugao in Portuguese India, from the nadir of 375,904 tons in 1933 to 864,698 tons in 1935. The opening of the new port at Vizagapatam has been the brightest feature in the Indian manganese industry during the last three years on account of the reduced lead from the Central Provinces to the sea. Table 24 shows the distribution of manganese ore exported from

British Indian ports (excluding Mormugao) during 1934 and 1935, from which it will be seen that the United Kingdom with an increase of some 21,000 tons retained her position as the chief importer of Indian manganese-ore. The second place as importer was held by Japan with an increase of some 91,000 tons, with France third with an increase of some 44,000 tons; Belgium showed an increase of 53,500 tons. In 1932 the exports to the United States of America, one of India's principal markets for manganese-ore, had ceased completely. In 1933 there was a trivial export to this destination but in 1935 the exports to the United States recovered to 77,760 tons.

TABLE 23.—*Exports of Manganese-ore during 1934 and 1935 according to ports of shipment.*

—	1934.	1935.
	Tons.	Tons.
Bombay	57,089	64,100
Calcutta	185,827	225,504
Vizagapatam	149,380	412,683
Mormugao (Portuguese India)	115,582	162,411
TOTAL	**507,878**	**864,698**

TABLE 24.—*Export of Manganese-ore from British Indian ports during the years 1934 and 1935.*

—	1934.			1935.		
	Quantity.	Value (£1 = Rs. 13·3).		Quantity.	Value (£1 = Rs. 13·3).	
	Tons.	Rs.	£	Tons.	Rs.	£
To—						
United Kingdom	161,430	34,22,910	257,362	182,816	36,03,322	270,926
Belgium	19,397	4,34,189	32,646	72,897	11,72,554	88,162
France	87,622	14,50,771	109,080	131,977	22,03,174	165,652
Japan	85,102	12,11,358	91,079	176,378	28,80,857	216,606
United States of America	30,083	5,45,920	41,047	77,760	14,32,422	107,701
Other countries	8,662	1,57,969	11,877	60,464	11,39,804	85,700
TOTAL	**392,296**	*72,23,112*	*543,091*	**702,287**	*1,24,32,133*	*934,747*

Mica.

There was a slight rise in the declared production of mica from 55,706 cwts. valued at Rs. 20,76,599 (£156,135) in 1934 to 58,754 cwts. valued at Rs. 25,52,612 (£191,926) in 1935. As has been frequently pointed out the output figures are incomplete, and a more accurate idea of the size of the industry is to be obtained from the export figures. In the years 1926 and 1927 the export figure was approximately double the reported production figure, whilst in the years 1928 and 1929 the quantity exported was more than double the reported production. In 1930 the recorded exports were, however, only some 57 per cent. in excess of the reported production, in 1931 36 per cent., in 1932 43 per cent., and in 1933 some 45 per cent. in excess. It was thought that this might mean that the Act referred to in the third paragraph was beginning to produce a definite effect : but as the excess of recorded exports over reported production has risen to 66 per cent. in 1934, and 141 per cent. in 1935, another possible interpretation is that measures are being found of circumventing the Act.

The United States of America and the United Kingdom, which are the principal importers of Indian mica, absorbed respectively 42·6 per cent. and 31·9 per cent. during 1934 and 49·6 per cent. and 26·4 per cent. during 1935. Germany took 10·8 per cent. and 9·0 per cent. respectively, of the total quantities exported during the years 1934 and 1935. The average value of the exported mica decreased from Rs. 64·7 (£4·9) per cwt. in 1934 to Rs. 56·7 (£4·3) in 1935. The exports rose from 92,918 cwts. valued at Rs. 60,30,525 (£453,423) in 1934 to 141,814 cwts., valued at Rs. 80,34,681 (£604,111) in 1935. The value recorded for 1932 was the lowest total value recorded since 1915-16 and it is pleasant that the tide, the turn of which was recorded in the 1933 Review, appears to be running so strongly.

The difference between exports and production is generally attributed to theft from the mines. If this be the only explanation we must assume that during the three years prior to 1930, and again in 1935, there had been as much mica stolen as won by honest means. Early in 1928 a bill was introduced into the Legislative Council of Bihar and Orissa, the purpose of which was an attempt to reduce the losses on this account by licensing miners and dealers; the bill was rejected. In March, 1930, however, a similar bill to regulate the possession and transport of, and trading in, mica was

passed. It was not, however, put into force until 1934. From the figures presented since 1930, as analysed above, it appears that this bill may have produced a good effect for the first few years, but that the effect has already disappeared.

TABLE 25.—*Quantity and value of Mica produced in India during the years 1934 and 1935.*

—	1934.			1935.		
	Quantity.	Value (£1 = Rs. 13·3).		Quantity.	Value (£1 = Rs. 13·3).	
	Cwts.	Rs.	£	Cwts.	Rs.	£
Bihar and Orissa—						
Gaya	12,679	2,88,996	21,729	10,524	4,55,696	34,263
Hazaribagh . . .	33,300	13,97,270	105,058	37,679	16,70,515	125,608
Manbhum . . .	..	..	..	29	872	66
Monghyr	..	..	..	442	11,648	876
Madras—						
Nellore	9,114	3,67,642	27,643	9,452	3,87,378	29,126
Nilgiris	75	8,429	634	43	7,136	536
Travancore State . .	..	..	..	41	3,500	263
Rajputana—						
Ajmer-Merwara . .	387	5,136	386	384	6,197	466
Jaipur State . . .	151	9,126	685	160	9,670	727
TOTAL .	55,706	*20,76,599*	*156,135*	58,754	*25,52,612*	*191,926*

TABLE 26.—*Quantity and value of Mica exported from India during the years 1934 and 1935.*

—	1934.			1935.		
	Quantity.	Value (£1 = Rs. 13·3).		Quantity.	Value (£1 = Rs. 13·3).	
	Cwts.	Rs.	£	Cwts.	Rs.	£
To—						
United Kingdom . .	29,606	31,06,625	233,581	37,519	38,52,105	289,632
Germany	10,013	5,65,451	42,515	12,813	6,18,889	46,529
France	1,763	1,47,282	11,074	3,642	3,70,253	27,838
United States of America . .	39,517	13,06,297	98,218	69,397	19,94,942	149,995
Other countries . .	12,019	9,04,870	68,085	18,443	11,98,542	90,117
TOTAL .	92,918	*60,30,525*	*453,423*	141,814	*80,34,681*	*604,111*

Monazite.

In its early years in India the monazite industry was of some importance and the output during the quinquennium 1914-1918 averaged annually 1,528 tons valued at £45,334. This prosperity continued only to 1921 and by 1925 the industry was moribund with a production of 1 cwt. only. There has since been a partial revival and the output for the period 1929-1933 averaged annually 215 tons valued at £2,114. In 1934 the output was 1,009 tons valued at £3,769 which rose to 3,819 tons valued at £12,453 in 1935. The decline of the industry from the high figures of 1914 to 1921 is of course due to the supplanting of incandescent mantles for gas lighting by electricity. The partial revival of the monazite industry is presumably due to the greatly increased output of ilmenite, the production of monazite as a bye-product rendering cheaper production possible.

Nickel.

As a bye-product in the smelting operations of the Burma Corporation, Limited, at Namtu, in the Northern Shan States, there is now a regular production of nickel-speiss, which, during the quinquennium 1929-1933 averaged annually 3,211 tons valued at Rs. 8,19,023 (£61,197). In 1933 the output was 3,350 tons, valued at Rs. 10,28,523 (£77,333), which rose in 1934 to 3,951 tons valued at Rs. 11,44,337 (£86,401). In 1935 the output was 4,850 tons, valued at Rs. 14,00,074 (£105,269), the composition being 30·20 per cent. of nickel, 10·10 per cent. of copper, 4·59 per cent. of cobalt, and 24·66 ozs. of silver to the ton. The speiss is shipped to Hamburg for further treatment.

Petroleum.

The world's production of petroleum in 1926 amounted to nearly 150 million long tons, of which India contributed 0·72 per cent. In 1927, this figure jumped to some 172 million long tons, of which the Indian proportion, on a practically stationary production, fell to 0·64 per cent. In 1928, there was another substantial rise in the world's production, which reached the figure of over 181 million tons. In 1929, there was another jump to over 202 million tons, but in 1930 the world's production fell to about 193½ million tons, in 1931 to about 187 million tons, and in 1932 to about 183 million

tons, whilst in 1933 the production rose again to about 202 million tons, in 1934 to about 215 million tons, and in 1935 to 233 million tons.[1] Decreases were shown by Poland, Sarawak, Egypt, Roumania and France. All other important producers showed an increase in production, by far the largest being due to Iraq, as a result of the opening of the pipe line to the Mediterranean. The United States contributed 60·9 per cent. of the world's supply in 1935, Russia 10·7 per cent., Venezuela 9·4 per cent., Roumania 3·9 per cent. and Iran 3·1 per cent. In 1928, India contributed 0·64 per cent., which fell to 0·60 per cent. in 1929 and rose to 0·62 per cent. in 1930, 0·63 per cent. in 1931, and 0·64 per cent. in 1932, and fell again to 0·62 per cent. in 1933, to 0·60 per cent. in 1934 and to 0·50 per cent. in 1935; her position on the list of petroleum producing countries fell from 11th in 1929 to 12th in 1930 to 1933, her place being taken by Trinidad, and to 13th in 1934 and 1935, due to the production by Iraq.

The production of petroleum in India (including Burma) increased slightly from 322,025,280 gallons in 1934 to 322,662,336 gallons in 1935, the highest figure in the history of the industry. The increase in 1935 is due to an increase of some 4 million gallons in Assam, almost offset by a decrease of 3½ million gallons in Burma. This increase in output in 1935 was accompanied by an increase in estimated value amounting to Rs. 22,73,5[illegible]0 (£170,[illegible]44).

The amount of gasolene produced from natural gas during the year was 9,717,087 gallons, of which 9,309,083 gallons were produced in Burma and 408,004 gallons in the Punjab.

The Yenangyaung field maintained its reputation of being one of the most wonderful oilfields in the world. The total production during 1935 was somewhat less than in the previous year but the resources of the field as a whole are sufficient to ensure an adequate supply of oil for many years.

At the end of 1935 there were 3,030 wells producing in the field. Besides a large number of wells drilled to shallow sands, this total includes 183 hand-dug wells whose continued existence is one of the interesting features of the field.

During the year further extensions of the producing areas on the eastern flank of the field were proved. In the southern part of the field valuable production was obtained from wells in the

[1] Compiled from World Petroleum of June, 1936.

southern part of Block 2S and the northern part of Block 4S. Within the Reserves and their Borders there were no noteworthy developments.

Satisfactory results continue to be obtained from gas drives in the leased blocks; in addition to gas drives, gas is also injected with the object of repressuring and storage. The major companies operating within the Reserves continued to co-operate in applying back pressures to youthful wells. Casing policies continue to be carefully designed to protect the oil sands against the danger of flooding by water and, in general, production methods throughout the field are characterised by a realisation of the importance of the conservation of oil and gas and the prevention of waste, whether simple or underground.

In 1935 there was a slight increase in the output from the Singu field. At the end of the year the total number of producing wells was 465 as compared with 459 in December, 1934. In addition, a number of wells remained cemented above productive sands. These wells can be drilled into productive sands in a very short time and the total field production substantially increased.

In the southern part of the field a valuable producing area was proved and at the end of the year competitive drilling was in progress along the boundary between Blocks 50E and 50N.

There has been no radical change in production methods during the year under report. The fundamental principle underlying the policy of the major operating company at Singu is to make these adjustments at each well which lead to a maximum oil recovery with a minimum production of gas. Wells with high gas-oil ratios are shut in, and the balance of casing-head gas remaining after the satisfaction of the field requirements is returned to dry gas sands for storage, or to certain areas for repressuring purposes. There is one gas drive in operation and the repressuring operations of the British Burmah Petroleum Company, Ltd., continued to give satisfactory results. During the year the Burmah Oil Company, Ltd., were actively engaged upon the construction of a training wall in the River Irrawaddy to reclaim a potentially productive area. Continuous gas lift on some wells producing from lower division sands and gas displacement pumping on wells producing from upper division sands were continued on a small scale, but production from the great majority of the wells in the field was obtained by ordinary pumping methods.

During 1935 there was a good deal of drilling activity at Yenangyat and, as a result, the total production from the Pakokku district, excluding Lanywa, shows a large increase. There was a further increase in the production from the Lanywa field during 1935. Back pressures are maintained on nearly all the wells in this model field, which is operated by the Indo-Burma Petroleum Company, Ltd. While a number of wells are pumped from a central power, the majority have individual pumping motors. The gasoline plant was operated throughout the year and gave a satisfactory yield.

In the Minbu district there were, at the close of the year, 378 producing wells. The total production showed little change. Apart from routine production there was very little activity in the district during the year.

There was a reduction during 1935 in the total production from the Indaw field. During the year all but one of the wells were successfully operated by the automatic gas lift system.

Production from the Padaukpin and Yenanma fields in the Thayetmyo district again showed an increase. Satisfactory progress was made in the drilling of the Burmah Oil Company's deep test well at Monatkon, but as yet no discoveries of importance have come to light.

The output from Kyaukpyu remained at its usual low level.

In Assam the output of the Digboi field increased slightly. There has been no drilling in outside areas in the Assam Valley.

In the Surma Valley there was no production and prospecting operations were concentrated on the drilling of the new well at Masimpur. Some progress was made, but much delay arose from serious fishing jobs caused by the extremely difficult drilling conditions brought about by the nature of the formation and the exceptionally high pressures.

In the Punjab the output from the Khaur field increased by over 200,000 gallons as compared with 1934. As a result of the indications from a deep test well into the underlying formations an old well was deepened to 5,408 feet in October last, giving satisfactory production. A further old well is at present in hand for the same objective, the depth of which at the end of the year was 4,860 feet.

On the Dhulian dome a well commenced last year has been carried to 7,653 feet and drilling is still in progress. The first

indication of oil was reported at 7,448 feet in September and the well was deepened carefully to 7,501 feet and at the beginning of November last flowed under low pressure at 100 barrels per day. This strike was tested for one month and production held up satisfactorily. The well was then deepened as it was apparent it was not yet into the limestones.

TABLE 27.—*Quantity and value of Petroleum produced in India during the years 1934 and 1935.*

—	1934.			1935.		
	Quantity.	Value (£1 = Rs. 13·3).		Quantity.	Value (£1 = Rs. 13 3).	
	Gals	Rs.	£	Gals.	Rs.	£
Assam—						
Digboi . .	63,754,262	1,08,86,609	818,542	67,886,586	1,15,92,246	871,597
Burma—						
Kyaukpyu . .	13,579			13,549		
Minbu . .	3,873,128			3,808,949		
Singu . . .	81,927,114			83,590,590		
Thayetmyo . .	685,489	(a) 4,82,77,033	3,629,852	916,702	(a) 4,98,63,495	3,749,135
Upper Chindwin .	3,095,245			2,788,591		
Yenangyat (including Lanywa).	27,717,552			30,414,737		
Yenangyaung .	137,447,963			129,810,946		
Punjab—						
Attock . .	3,510,948	8,77,737	65,905	3,436,776	8,59,194	64,601
TOTAL .	**322,025,280**	*6,00,41,379*	*4,514,389*	**222,662,336**	*6,23,14,929*	*4,685,333*

(*a*) Estimated.

TABLE 28.—*Imports of Kerosene Oil into India during the years 1934 and 1935.*

—	1934.			1935.		
	Quantity.	Value (£1 = Rs. 13 3).		Quantity.	Value (£1 = Rs 13 3).	
From—	Gals.	Rs.	£	Gals	Rs.	£
Union of Socialist Soviet Republics.	43,121,886	1,53,92,706	1,157,346	43,466,478	1,38,17,304	1,038,805
Roumania . .	8,796,256	25,17,500	189,286	1,013,409	2,91,792	21,939
Sumatra . .	6,772,813	31,66,052	238,048	4,689,877	20,33,078	152,863
Borneo . .	.			5,890,997	20,60,810	154,948
Iran . . .	1,971,850	10,59,061	79,629	12,507,372	64,81,591	487,338
Java . . .	1,422,981	2,94,709	22,159	2	1	.
United States of America.	2,118,839	12,78,786	96,149	330,092	2,95,034	22,183
Other countries .	390,431	2,49,649	18,771	750,164	4,82,508	36,279
TOTAL .	**64,595,055**	*2,39,58,463*	*1,801,388*	**68,649,391**	*2,54,62,118*	*1,914,435*

TABLE 29.—*Imports of Fuel Oils into India during the years 1934 and 1935.*

—	1934.			1935.		
	Quantity.	Value (£1 = Rs. 13·3).		Quantity.	Value (£1 = Rs. 13·3).	
	Gals.	Rs.	£	Gals.	Rs.	£
From—						
Union of Socialist Soviet Republics.	912,132	1,30,956	9,846	966,060	1,44,274	10,848
Roumania . .	2,165,569	3,73,907	28,114	20	6	..
Iran . . .	77,150,970	1,36,50,208	1,026,331	98,264,798	1,63,30,412	1,227,851
Borneo . .	25,466,739	43,50,602	327,113	31,828,024	51,55,392	387,623
Other countries .	876,027	2,59,411	19,505	434,945	1,00,884	7,585
TOTAL .	**106,571,437**	*1,87,65,084*	*1,410,909*	**131,493,847**	*2,17,30,968*	*1,633,907*

TABLE 30.—*Exports of Paraffin Wax from India during the years 1934 and 1935.*

—	1934.			1935.		
	Quantity.	Value (£1 = Rs. 13·3).		Quantity.	Value (£1 = Rs. 13·3).	
	Tons.	Rs.	£	Tons.	Rs.	£
To—						
United Kingdom	11,419	49,56,754	372,688	15,366	65,26,363	490,704
Germany . .	1,855	7,82,410	58,828	205	87,500	6,579
Netherlands .	4,778	20,07,038	150,905	5,103	21,85,027	164,288
Belgium . .	3,628	15,32,603	115,233	3,002	12,66,691	95,240
Italy . .	4,326	15,66,973	117,818	3,411	13,54,178	101,818
China . .	2,530	10,20,600	76,737	2,300	9,66,000	72,632
Union of South Africa.	1,958	7,80,235	58,664	2,607	10,79,526	81,167
Portuguese East Africa.	4,271	16,35,003	122,933	4,867	20,35,416	153,039
Canada . .	2,142	8,99,640	67,641	1,539	6,46,380	48,600
United States of America.	2,751	11,50,712	86,520	2,322	9,76,920	73,453
Mexico . .	4,300	18,06,000	135,790	4,250	17,85,000	134,211
Argentine Republic.	436	1,83,225	13,776	131	55,125	4,145
Chile . .	350	1,47,000	11,053	4,527	18,76,840	141,115
Australia . .	412	1,73,740	13,063	431	1,82,140	13,694
Other countries	1,960	8,21,248	61,748	3,141	13,03,627	98,017
TOTAL .	**47,116**	*1,94,63,181*	*1,463,397*	**53,202**	*2,23,26,733*	*1,678,702*

There was an increase (over 4 million gallons) in the imports of kerosene, due mainly to an increase of over 10½ million gallons from Iran and nearly 6 million gallons from Borneo, offset in part by important decreases from all other countries except Russia, the imports from which showed only a slight fall (*see* Table 28).

There was a rise of 25 million gallons in the quantity of fuel oil imported into India, the principal change being an increase of over 21 million gallons from Iran and of over 6 million gallons from Borneo and a fall of over 2 million gallons from Roumania. Some 75 per cent. of the supply was derived from Iran and some 24 per cent. from Borneo (*see* Table 29).

The exports of paraffin wax showed an increase amounting to some 6,000 tons (*see* Table 30).

Salt.

There was a slight fall, during 1935, in the total output of salt (accompanied by a trifling increase in value), due to a decrease of 39,000 tons in Madras, all the other provinces showing increases; the 1934 production was the highest on record. Imports of salt into India increased by nearly 2,000 tons, all the countries of origin showing decreases excepting Germany from which 30,000 tons were received above the imports of the previous year, and the United Kingdom, from which the imports are negligible.

TABLE 31.—*Quantity and value of Salt produced in India during the years 1934 and 1935.*

—	1934.			1935.		
	Quantity.	Value (£1 = Rs. 13 3).		Quantity.	Value (£1 = Rs. 13 3).	
	Tons.	Rs.	£	Tons.	Rs.	£
Aden	335,415	20,44,905	153,752	339,667	19,81,299	148,970
Bengal	28	371	28	17	1,079	81
Bombay and Sind	620,972	(*a*)26,75,218	201,144	633,700	31,02,656	233,282
Burma	36,976	5,33,916	40,144	40,086	5,31,009	39,925
Gwalior (*b*)	66	3,249	244	95	4,725	355
Madras	499,268	25,94,094	195,045	460,257	22,89,790	172,165
Northern India	470,977	38,21,929	287,363	474,351	37,78,579	284,104
TOTAL	1,963,702	*1,16,73,682*	*877,720*	1,948,173	*1,16,89,137*	*878,882*

(*a*) Excludes the value of 9,495 tons of salt produced in Sind.
(*b*) Figures relate to the official years, 1934-35 and 1935-36.

TABLE 32.—*Quantity and value of Rock-Salt produced in India during the years 1934 and 1935.*

—	1934.			1935.		
	Quantity.	Value (£1 = Rs. 13·3).		Quantity.	Value (£1 = Rs. 13·3).	
	Tons	Rs.	£	Tons	Rs.	£
Salt Range . .	155,900	11,92,638	89,672	153,347	11,73,107	88,204
Kohat . . .	19,188	60,128	4,521	21,003	64,708	4,865
Mandi . . .	4,133	1,08,718	8,174	4,002	1,08,477	8,156
TOTAL .	179,171	*13,61,484*	*102,367*	178,352	*13,46,292*	*101,225*

TABLE 33.—*Imports of Salt into India during the years 1934 and 1935.*

—	1934.			1935.		
	Quantity.	Value (£1 = Rs. 13·3).		Quantity.	Value (£1 = Rs. 13·3).	
From—	Tons	Rs.	£	Tons	Rs.	£
United Kingdom .	496	74,591	5,608	1,236	93,585	7,037
Germany .	56,348	8,93,873	67,208	86,337	14,70,251	110,545
Aden and Dependencies.	310,023	39,54,992	297,368	298,749	40,72,470	306,201
Egypt . . .	12,824	1,64,231	12,348	7,565	1,22,193	9,187
Italian East Africa	12,375	1,70,939	12,853	.	..	..
Other countries .	109	7,999	601	85	5,763	433
TOTAL .	392,17[illegible]	*52,66,625*	*395,986*	393,972	*57,64,262*	*433,403*

Saltpetre.

Although complete statistics of production of saltpetre in India are no longer available (*see Rec. Geol. Surv. Ind.*, LXIV, p. 289), yet the export figures may be accepted as a fairly reliable index to the general state of the industry, for, excepting a few hundreds of tons required for internal consumption as fertiliser, most of the output is exported to foreign countries. The quantity exported increased from 166,282 cwts. valued at Rs. 13,38,171 (£100,614) in 1934 to 173,259 cwts. valued at Rs. 13,35,583 (£100,420) in 1935. Nevertheless, figures of production of refined saltpetre—without values—are available for tracts worked under the supervision of

the Northern India Salt Revenue Department. The production figures for the financial years 1934-35 and 1935-36 are :—

	1934-35.	1935-36.
	Tons.	Tons.
Bihar	2,327	2,953
Punjab	6,029	7,727
United Provinces	2,446	1,943
TOTAL	10,802	12,623

These figures happen to be greater than the export figures, indicating that there is an internal market for a portion of the output.

A certain amount of nitrate of potash is used for agricultural purposes on the tea gardens of India. During the war, when it was impossible to obtain supplies of imported potash, the amount of locally produced nitrate utilised in this way reached an appreciable figure. The practice continued and the quantity estimated to have been absorbed for fertilising purposes on tea gardens in 1935 was 900 tons against 700 tons in 1934.

TABLE 34.—*Distribution of Saltpetre exported from India during the years 1934 and 1935.*

—	1934.			1935.		
	Quantity.	Value (£1 = Rs. 13·3).		Quantity.	Value (£1 = Rs. 13·3).	
To—	Cwts.	Rs.	£	Cwts.	Rs.	£
United Kingdom	27,544	2,15,020	16,167	55,059	4,25,040	31,958
Ceylon	42,438	2,75,207	20,692	17,450	1,10,910	8,339
Straits Settlements	5,712	83,074	6,246	4,320	49,667	3,734
Mauritius and Dependencies.	68,717	5,68,655	42,756	72,033	5,53,409	41,610
Other countries	21,871	1,96,215	14,753	24,397	1,96,557	14,779
TOTAL	166,282	*13,38,171*	*100,614*	173,259	*13,35,583*	*100,420*

Silver.

The production of silver from the Bawdwin mines of Upper Burma during 1935 rose slightly by 33,894 ozs. as compared with

1934, but this was accompanied by a great rise in value of Rs. 27,50,283 (£206,788) due to the increase in the price of silver during the year (*see* Table 2 and Lead, p. 259).

The output of silver obtained as a bye-product from the Kolar gold mines of Mysore showed a fall of 1,014 ozs.

The amount of silver bullion and coin exported during the year was 71,955,874 ozs., valued at Rs. 10,67,89,988 (£8,029,322), as compared with 53,991,714 ozs. valued at Rs. 7,26,70,511 (£5,463,948) during 1934.

TABLE 35.—*Quantity and value of Silver produced in India during the years 1934 and 1935.*

—	1934.			1935.		
	Quantity.	Value (£1 = Rs. 13·3).		Quantity.	Value (£1 = Rs. 13·3).	
	Ozs.	Rs.	£	Ozs.	Rs.	£
Bihar and Orissa— Manbhum . .	14	19	1	16	24	2
Burma— Northern Shan States.	5,792,019	74,44,482	559,736	5,825,913	1,01,94,765	766,524
Mysore— Kolar .	25,491	41,494	3,120	24,477	38,952	2,928
TOTAL .	5,817,524	*74,85,995*	*562,857*	5,850,406	*1,02,33,741*	*769,454*

Tin.

A further increase though trifling has to be recorded in the production of tin concentrates from Burma including Karenni State from 5,801·2 tons valued at Rs. 1,01,70,348 (£764,688) in 1934 to 5,859·7 tons valued at Rs. 1,01,48,976 (£763,081) in 1935. This is the highest quantity yet recorded in any one year but is accompanied by a slight fall in value. All districts show increases, except Karenni, the decrease from which reduces the surplus over the 1934 output to 58·5 tons. Of the total production of 1935 4,402·8 tons, or some 75 per cent., came from Burma proper, the balance of 1,456·9 tons being derived from Mawchi in Karenni State. There was no reported output of block tin.

Imports of unwrought tin rose from 44,479 cwts. valued at Rs. 67,75,268 (£509,419) in 1934 to 50,990 cwts. valued at Rs. 75,71,672 (£569,298) in 1935; 96 per cent. of these imports came from the Straits Settlements.

TABLE 36.—*Quantity and value of Tin concentrates produced in India during the years 1934 and 1935.*

—	1934.			1935.		
	Quantity.	Value (£1 = Rs. 13·3).		Quantity.	Value (£1 = Rs. 13·3).	
	Tons	Rs.	£	Tons	Rs.	£
Burma—						
Amherst . .	32·6	50,632	3,807	39 7	59,431	4,468
Mergui . .	1,357·3	22,90,102	172,188	1,755 9	29,69,512	223,272
Tavoy . .	2,512 0	45,00,064	338,351	2,601·7	45,88,339	344,988
Thaton . .	5·3	8,990	676	5·5	8,343	627
Karenni State .	1,894·0	(*a*)33,20,560	249,666	1,456 9	(*a*)25,23,351	189,726
TOTAL .	5,801·2	*1,01,70,348*	*764,688*	5,859·7	*1,01,48,976*	*763,081*

(*a*) Estimated.

TABLE 37.—*Imports of unwrought Tin (blocks, ingots, bars and slabs) into India during the years 1934 and 1935.*

—	1934.			1935.		
	Quantity.	Value (£1 = Rs. 13 3).		Quantity.	Value (£1 = Rs. 13 3).	
	Cwts.	Rs.	£	Cwts.	Rs.	£
From—						
United Kingdom .	1,825	2,12,549	15,981	1,407	2,11,513	15,903
Straits Settlements	43,143	65,60,941	493,304	49,099	73,19,156	550,312
Other countries .	11	1,778	134	484	41,003	3,083
TOTAL .	44,479	*67,75,268*	*509,419*	50,990	*75,71,672*	*569,298*

Tungsten.

An appreciable increase both in quantity and value of the output of wolfram from Burma has to be recorded, namely from 3,328·5 tons valued at Rs. 37,89,921 (£284,956) in 1934 to 3,837·1 tons, valued at Rs. 39,46,027 (£296,693) in 1935, though the price per unit declined from 37·17 shillings in 1934 to 34·42 shillings in 1935. The only years of higher recorded production are 1917, 1918 and 1919, the peak production being 4,542 tons in 1917. Higher values were recorded during 1915 to 1919. The rise in output during 1935 was shared by all producing districts in Burma proper, chiefly by Tavoy, but was reduced by a decrease of about 700 tons from

Karenni. Of this production 2,549·1 tons, or 66 per cent., came from Burma proper, the balance being derived from Mawchi in Karenni State.

TABLE 38.—*Quantity and value of Tungsten concentrates produced in India during the years 1934 and 1935.*

—	1934.			1935.		
	Quantity.	Value (£1 = Rs. 13·3).		Quantity.	Value (£1 = Rs. 13·3)	
Burma—	Tons	Rs.	£	Tons	Rs.	£
Mergui . .	121·8	77,046	5,793	223·1	1,55,943	11,725
Tavoy . .	1,201·7	14,26,744	107,274	2,089·1	21,98,773	164,945
Thaton . .	10·0	14,225	1,069	42·5	34,607	2,602
Yamethin . .	..	..	..	185·4	2,31,725	17,423
Karenni State .	1,995·0	(*a*)22,71,906	170,820	1,288·0	(*a*)13,24,579	99,592
Mong Pai State .	..	..	..	9·0	5,400	406
TOTAL	3,328·5	*37,89,921*	*284,956*	3,837·1	*39,46,027*	*296,693*

(*a*) Estimated.

Zinc.

The production of zinc concentrates by the Burma Corporation Limited, in the Northern Shan States, rose from 68,838 tons valued at Rs. 26,77,413 (£201,309) in 1934 to 78,590 tons valued at Rs. 37,99,358 (£285,666) in 1935. The quantity is the greatest hitherto recorded, but the value is much below those of the years 1926 to 1929 (£559,412 in 1928). The exports during the year under review amounted to 76,599 tons valued at Rs. 28,75,272 (£216,186) against 77,514 tons valued at Rs. 29,46,693 (£221,556) in the preceding year.

Zircon.

The output of zircon, a mineral obtained as a concurrent product in the collection of ilmenite and monazite in Travancore State increased from 380 tons valued at £1,030[1] in 1934 to 6,654 tons valued at £6,967 in 1935. The increase accompanied large increases in the production of ilmenite and monazite.

[1] Revised.

III.—MINERALS OF GROUP II.

Amber.

The production of amber in the Myitkyina district, Burma, decreased from 29·5 cwts., valued at Rs. 12,020 (£897) in 1928, to 19·6 cwts. valued at Rs. 6,080 (£454) in 1929, and 2·1 cwts. valued at Rs. 730 (£54) in 1930. There was no reported output in 1931, but in 1932 there was an output of 11·5 cwts. valued at Rs. 1,940 (£146), in 1933 of 76 lbs. valued at Rs. 1,500 (£113), in 1934 of 3·7 cwts. valued at Rs. 152 (£12), and in 1935 of 18·6 cwts., valued at Rs. 2,100 (£158).

Apatite.

The production of apatite in the Singhbhum district, Bihar and Orissa, was 22 tons valued at Rs. 3,300 (£244) in 1930, but *nil* in 1931 to 1935. The output of apatite in the Trichinopoly district, Madras, rose from 37 tons valued at Rs. 372 (£28) in 1933 to 59 tons valued at Rs. 885 (£67) in 1934, and 102 tons valued at Rs. 1,532 (£115) in 1935

Aquamarine.

The output of aquamarine from the deposits of Daso in Ladakh in Kashmir rose from 686 tolas (39,000 carats) valued at Rs. 686 (£52) in 1933 to 1,221 tolas (69,471 carats) in 1934. The value of the 1934 production was not reported and there has been no production during 1935.

Asbestos.

The total production of asbestos in India during 1931 was 25·4 tons valued at Rs. 4,140 (£311), made up of 20 tons valued at Rs. 2,500 (£188) from Singhbhum and 5·4 tons valued at Rs. 1,640 (£123) from the Cuddapah district, Madras. In 1935 the production amounted to 62·7 tons compr sed of 2·7 tons valued at Rs. 1,267 (£95) from the Cuddapah district, and 60 tons valued at Rs. 3,300 (£248) from Seraikela State in Singhbhum.

Barytes.

The production of barytes in India rose from 3,813 tons valued at Rs. 35,263 (£2,651) to 5,493 tons valued at Rs. 34,954 (£2,628) in 1935. As in 1934 the chief producing districts were Cuddapah and Kurnool in the Madras Presidency. There was an increased production in Alwar State.

Bauxite.

In 1930, 2,514 tons of bauxite were produced, of which 719 tons came from the Kaira district of Bombay, and 1,795 tons from the Jubbulpore district of the Central Provinces. In 1931 the output from the Jubbulpore district was 4,298 tons, in 1932 4,467 tons, and in 1933 1,000 tons valued at Rs. 3,000 (£226). In 1934 the output was reduced to only

18 tons valued at Rs. 90 (£7), from the Jubbulpore district, but rose in 1935 to 7,635 tons valued at Rs. 15,270 (£1,148).

TABLE 39.—*Quantity and value of Barytes produced in India during the years 1934 and 1935.*

—	1934.			1935.		
	Quantity.	Value (£1 = Rs. 13·3).		Quantity.	Value (£1 = Rs. 13·3).	
	Tons	Rs.	£	Tons	Rs.	£
Bihar and Orissa—						
Manbhum	180	1,080	81	104	624	47
Madras—						
Anantapur	100	625	47	..	..	..
Cuddapah	2,536	25,222	1,896	3,626	20,500	1,541
Kurnool	623	4,596	346	936	5,560	418
Rajputana—						
Alwar State	374	3,740	281	827	8,270	622
TOTAL .	3,813	*35,263*	*2,651*	5,493	*34,954*	*2,628*

In Jaipur State, Rajputana, 20 cwts. of beryl were extracted in 1930; no value was reported. There was no output in 1931, but in 1932 there was a production in Ajmer-Merwara of 281 tons valued at Rs. 5,281 (£397) which rose to 324 tons valued at Rs. 7,261 (£546) in 1933, falling to 55 tons valued at Rs. 1,650 (£124) in 1934, but rising in 1935 to 139 tons valued at Rs. 8,519 (£641). This beryl is being shipped to Germany and the United States of America for use as beryllium-ore, *i.e.*, for the extraction of the metal. The Indian beryl is of high grade and fetches from £7 to £10 per ton *c.i.f.* in America and Europe, so that it is obviously under-valued in the returns. There appears to be no previous example of the production anywhere in the world of beryl on such a large scale.

Beryl.

The production of native bismuth from the Tavoy district, Burma, fell from 112 lbs. valued at Rs. 323 (£24) in 1930, to 42 lbs. valued at Rs. 84 (£6) in 1931, and 27 lbs. valued at Rs. 54 (£4) in 1932; it rose again to 80 lbs. valued at Rs. 160 (£12) in 1933. There was no recorded production in 1934, but in 1935, 224 lbs. valued at Rs. 211 (£16) were produced.

Bismuth.

Borax.

Borax is sometimes produced from the Puga valley in the Ladakh *tahsil* of Kashmir State, the last reported production being of 7·3 cwts. in 1929. A contract to work these deposits has been given out for 10 years on an annual payment of Rs. 80, but no output was reported for 1934 and 1935.

Building materials and road-metal.

The total estimated value of building materials, and road-metal produced in the year under consideration was Rs. 1,17,73,031 (£885,190) against Rs. 1,14,39,551 (£860,116) in 1934. Certain returns supplied in cubic feet have been converted into tons on the basis of certain assumed relations between volume and weight.

The production of limestone and kankar during the year amounted to nearly 3½ million tons, and if weight of material won were the criterion then limestone would be rated next to coal in order of importance. The increased output of limestone of recent years is partly due to its use as a flux in the iron and steel industry and in the manufacture of cement.

Clays.

There was a fall in the output of clays from 367,305 tons valued at Rs. 3,43,222 (£25,806) in 1934 to 311,949 tons valued at Rs. 3,93,557 (£29,591) in 1935. This fall is due to a large decrease in the outputs of Assam, Bihar and Orissa, Central Provinces and Madras. Practically the whole of the large production of Madras is from Travancore State for the manufacture of tiles and bricks.

Columbite.

An output of 100 lbs. of columbite valued at Rs. 60 (£4) was reported from the Monghyr district, Bihar and Orissa, during 1931. There was no output during 1932 to 1935.

Corundum.

The production of corundum in the Salem district, Madras, amounted to 30 tons valued at Rs. 2,189 (£162) in 1930, but since then there has been no production until 1935, when 28 tons valued at Rs. 6,181 (£465) were produced. There was, however, an output of 56,560 tolas (13 cwts.) of corundum and of 13,718 tolas (3 cwts.) of sapphire with corundum in 1934 and 1935, respectively, from Soomjam in the Padar district of Kashmir, this was described as 'uncommercial material'. It is additional to the gem sapphire recorded elsewhere (*see* page 288).

TABLE 40.—*Production of Building Materials and*

	GRANITE AND GNEISS.		LATERITE.		LIME.		LIMESTONE AND KANKAR.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons	Rs.	Tons	Rs.	Tons	Rs.	Tons	Rs.
Assam . . .	8,234	15,712	19,811	22,709	..	..	57,324	81,150
Bengal . . .	161,165	1,63,287	..	..	..	..	..	..
Bihar and Orissa .	637,121	7,09,290	2,463	644	..	..	(a) 1,085,315	20,81,933
Bombay . . .	114	3	7,029	5,262	..	..	800	2,650
Burma . . .	186,473	3,38,540	152,686	1,50,244	..	..	374,105	4,48,162
Central India . .	..	..	..	..	36,236	2,27,627	165,131	67,248
Central Provinces .	11,533	9,357	..	..	..	..	537,874	5,30,601
Delhi . . .	..	..	..	..	..	..	..	..
Gwalior . .	..	..	..	..	..	..	60,843	32,547
Kashmir . .	..	..	..	..	..	..	560	(b)
Madras . .	120,665	1,39,203	..	..	..	..	75,285	45,946
Mysore . . .	7,590	2,20,067	..	..	1,958	31,572	8,159	13,037
North-West Frontier Province.	..	..	..	..	..	..	424	43
Punjab . . .	57,928	51,238	..	..	..	..	230,499	1,95,763
Rajputana . .	..	..	..	..	..	..	(c) 346,349	5,96,236
United Provinces .	8,679	7,739	..	..	..	..	584,286	4,92,104
TOTAL .	1,199,502	*16,54,436*	181,989	*1,78,949*	38,194	*2,59,199*	3,488,418	*45,91,020*

(a) Includes 55,722
(b) Not reported.
(c) Includes 74 tons

Road-metal in India during the year 1935.

MARBLE.		SANDSTONE.		SLATE.		TRAP.		MISCELLANEOUS.		Total Value (£1 = Rs. 13 3)	
Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.		
Tons	Rs.	Tons	Rs.	Tons	Rs.	Tons	Rs.	Tons	Rs.	Rs.	£
..	..	2,330	4,358	..	..	..	..	353,051	4,49,737	5,73,756	43,140
..	..	..	..	..	..	..	..	..	..	1,63,287	12,277
..	..	45,386	37,627	1,329	25,380	228,043	2,45,451	244,268	2,14,303	33,14,628	249,220
..	..	..	..	..	..	433,287	6,33,249	49,554	38,537	6,79,701	51,105
..	..	58,435	91,295	..	..	..	..	759,270	5,80,991	16,09,232	120,995
..	..	..	..	..	..	..	..	6,305	8,616	3,03,491	22,819
..	..	..	..	..	..	9,576	7,400	87,835	24,801	5,72,159	43,019
..	..	..	..	..	..	..	..	34,179	24,447	24,447	1,838
..	..	12,533	14,494	..	..	..	..	..	..	47,041	3,537
..	..	..	..	..	..	..	..	1,332	349	349	26
..	..	..	..	..	..	..	..	574,711	3,65,577	5,50,726	41,408
..	..	..	..	36	133	..	..	297,961	3,12,702	5,77,511	43,422
..	..	..	..	..	..	..	..	..	..	43	3
..	..	..	..	7,035	1,35,351	..	..	122,786	1,31,719	5,17,071	38,878
5,828	1,98,187	193,710	6,83,980	105	1,350	..	..	100,090	56,335	15,36,088	115,495
..	..	20,586	14,039	2,645	19,799	..	..	436,750	7,66,220	12,99,901	97,737
5,828	*1,98,187*	**332,980**	*8,45,793*	**11,150**	*1,82,013*	**670,906**	*8,86,100*	**3,068,092**	*29,77,334*	*1,17,73,031*	*885,190*

tons of dolomite.

of dolomite.

TABLE 41.—*Production of Clays in India during 1935.*

—	1935.		
	Quantity.	Value (£1=Rs. 13·3).	
	Tons	Rs.	£
Assam	3,936	3,936	296
Bengal	17,716	24,544	1,845
Bihar and Orissa	35,118	1,85,212	13,926
Burma	25,898	28,146	2,116
Central India	2,669	3,412	257
Central Provinces	37,962	39,172	2,945
Delhi	37,108	32,212	2,422
Gwalior	520	1,422	107
Madras	110,569	39,003	2,933
Mysore	10,862*	24,277	1,825
Punjab	28,782	10,479	788
Rajputana	809	1,742	131
TOTAL	311,949	*3,93,557*	*29,591*

Felspar. The output of felspar in 1934 was 628 tons valued at Rs. 6,311 (£474), which rose in quantity to 702 tons in 1935, with a fall in value, however, to Rs. 4,943 (£372). This total is made up of 47 tons from the Bangalore district, Mysore valued at Rs. 311, 55 tons from Alwar State, Rajputana, valued at Rs. 223 and 600 tons from Ajmer-Merwara valued at Rs. 4,409.

Fuller's earth. There was a fall in the reported production of fuller's earth from 8,526 tons in 1934 to 7,644 tons in 1935. The decrease was mainly from Bikaner State, Rajputana,

TABLE 42.—*Quantity and value of Fuller's Earth produced in India during the years 1934 and 1935.*

—	1934.			1935.		
	Quantity.	Value (£1 = Rs. 13 3).		Quantity.	Value (£1 = Rs. 13·3).	
	Tons	Rs.	£	Tons	Rs.	£
Bombay—						
Hyderabad (Sind) . .	821	17,503	1,316	685	13,349	1,004
Khairpur State (Sind) .	4,281	(*a*) 42,810	3,219	4,201	(*a*) 42,010	3,158
Central Provinces—						
Jubbulpore	25	123	9	44	216	16
Rajputana—						
Bikaner State	2,213	15,637	1,176	1,437	11,147	838
Jaisalmer State .	18	195	15	17	193	15
Jodhpur State	1,168	14,000	1,052	1,260	15,000	1,128
TOTAL .	**8,526**	*90,268*	*6,787*	**7,644**	*81,915*	*6,159*

(*a*) Estimated.

Garnet.

In 1934 there was an output of 225 tons of garnet sand valued at Rs. 2,250 (£169) in the Tinnevelly district, Madras, which increased to 325 tons, valued at Rs. 3,250 (£244) in 1935.

Graphite.

There was an output in 1934 of 337 tons of graphite valued at Rs. 4,816 (£359) comprised of 99 tons valued at Rs. 49 from the Betul district, Central Provinces, and 238 tons valued at Rs. 4,767 from the Kolar district, Mysore. In 1935 this rose to 557 tons valued at Rs. 11,481 (£863), composed of 406 tons valued at Rs. 9,274 from the Betul district, 150 tons valued at Rs. 2,157 from the Kolar district, and 1 ton valued at Rs. 50 from Vizagapatam district, Madras.

Gypsum.

There was a slight fall in the output of gypsum from 46,757 tons valued at Rs. 91,241 (£6,860) in 1934 to 45,318 tons valued at Rs. 92,363 (£6,945) in 1935, with slight rise in value. The Jodhpur output increased by 5,000 tons, but was more than counterbalanced by decreases in Bikaner and Jhelum districts.

TABLE 43.—*Quantity and value of Gypsum produced in India during the years 1934 and 1935.*

—	1934.			1935.		
	Quantity.	Value (£ = Rs. 13·3).		Quantity.	Value (£1 = Rs. 13·3).	
	Tons	Rs.	£	Tons	Rs.	£
Kashmir State	165	1,125	85	..	..	..
Madras—						
Trichinopoly	55	560	42	528	3,275	246
Punjab—						
Jhelum	17,218	22,562	1,696	11,915	13,577	1,021
Rajputana—						
Bikaner State	4,049	9,919	746	2,580	7,276	547
Jaisalmer State	270	1,075	81	295	1,235	93
Jodhpur State	25,000	56,000	4,210	30,000	67,000	5,038
TOTAL	46,757	*91,241*	*6,860*	45,318	*92,363*	*6,945*

Miscellaneous refractory minerals.

The output of kyanite and quartzite and related rocks in Bihar and Orissa is becoming increasingly important, partly for purposes of export, and partly for use in India, such as for furnace linings at Jamshedpur. The data for 1934 and 1935, which all relate to the Singhbhum district—except for 4 tons of quartzite produced in Ajmer-Merwara, Rajputana, in 1934 and for 29 tons of kyanite from the Mysore State in 1934, are assembled in Table 44, from which it will be seen that there has been an increase in total output from 21,548 tons valued at Rs. 1,79,801 (£13,519) in 1934 to 43,724 tons, valued at Rs. 4,03,003 (£30,301) in 1935. The most valuable of these materials is kyanite extracted for export by the Indian Copper Corporation from Lopso Hill in Kharsawan.

TABLE 44.—*Quantity and value of Miscellaneous Refractory Materials produced in Bihar and Orissa during the years 1934 and 1935.*

—	1934.			1935.		
	Quantity.	Value (£1 = Rs. 13·3).		Quantity.	Value (£1 = Rs. 13·3).	
	Tons	Rs.	£	Tons	Rs.	£
Kyanite	(a) 9,411	1,43,113	10,760	19,903	3,24,055	24,365
Quartz-mica-schist . .	1,813	17,830	1,341	4,702	46,943	3,530
Quartzite	(b) 10,324	18,858	1,418	19,119	32,005	2,406
TOTAL .	21,548	*1,79,801*	*13,519*	43,724	*4,03,003*	*30,301*

(a) Includes the production of 29 tons of kyanite in Mysore State.
(b) Includes 4 tons of quartzite produced in Ajmer-Merwara, Rajputana.

Ochre.

There was a decrease in the reported production of ochre from 9,614 tons valued at Rs. 43,328 (£3,258) in 1934, to 8,190 tons valued at Rs. 40,993 (£3,082) in 1935 Central India and the Central Provinces were mainly responsible for this decrease.

TABLE 45.—*Quantity and value of Ochre produced in India during the years 1934 and 1935.*

—	1934.			1935.		
	Quantity.	Value (£1 = Rs. 13·3).		Quantity.	Value (£1 = Rs. 13·3).	
	Tons	Rs.	£	Tons	Rs.	£
Bihar and Orissa . . .	50	500	38	352	1,638	123
Central India . . .	(a) 3,400	23,049	1,733	3,292	22,942	1,725
Central Provinces . . .	4,714	10,039	755	3,297	8,165	614
Gwalior	548	3,488	262	437	2,731	205
Kashmir	93	(b)	..	..	..	..
Madras	251	2,365	178	427	3,656	275
Rajputana	390	2,701	203	311	1,378	104
United Provinces . . .	168	1,186	89	74	480	36
TOTAL .	9,614	*43,328*	*3,258*	8,190	*40,993*	*3,082*

(a) Revised.
(b) Not reported.

Ruby, Sapphire and Spinel.

Since the liquidation of the Burma Ruby Mines, Limited, and the final cessation of the operations of this company in 1931, there has been an interregnum during which reliable statistics of production of gem stones in the Mogok Stone Tract have been unobtainable. Work, however, is still continued by local miners; in addition a certain amount of work is being done under extraordinary licenses. For 1932 no returns were available, except that a fine ruby of 17 carats was found at Chaunggyi near Mogok, and a fine sapphire of about 90 carats and a good star sapphire of 453 carats were mined at Katha. For 1933 the only return was of 1,103 carats of rubies from Katha. For 1934, however, there is a reported production of 21,622 carats of rubies valued at Rs. 36,011 (£2,708) and 153 carats of sapphire valued at Rs. 330 (£25), and for 1935 98,753 carats of rubies valued at Rs. 1,10,213 (£8,287), 202 carats of sapphires, valued at Rs. 329 (£25) and 6,687 carats of spinels valued at Rs. 3,850 (£289). The data for 1933, 1934 and 1935 relate to production under extraordinary licenses.

In addition, the production was reported from Soomjam in the Padar district of Kashmir State, of 13,696 tolas (798,929 carats) of sapphire, the value of which has not yet been determined. There was also a production of about 3 cwts. of sapphire with corundum of no commercial value (*see* page 281). The sapphire deposits of Kashmir have long been known, but on account of their high altitude they are worked only occasionally.

TABLE 461.—*Quantity and value of Ruby, Sapphire and Spinel produced in India during the years 1934 and 1935.*

—	1934.			1935.		
	Quantity.	Value (£1 = Rs. 13·3).		Quantity.	Value (£1 = Rs. 13·3)	
	Carats	Rs.	£	Carats	Rs.	£
Burma—						
Katha . .	21,622 (Rubies)	36,011	2,708	98,753 (Rubies)	1,10,213	8,287
	153 (Sapphires)	330	25	(*a*) 202 (Sapphires)	329	25
	..	..	..	6,687 (Spinel)	3,850	289
Kashmir State .	1,071,869 (Sapphires)	1,38,961	10,448	798,929 (Sapphires).	(*b*)	..
TOTAL .	1,093,644	*1,75,302*	*13,181*	904,571	*1,14,392*	*8,601*

(*a*) Excludes 2,272 carats valued at Rs. 74 only.
(*b*) Value not yet determined.

The output of soda (*phulli*) in Kashmir State was 7 tons valued at Rs. 194 (£15) in 1934; the production in 1935 was *nil*.

Soda.

There was no recorded production of *trona* or *urao* from the Lonar Lake, in the Buldana district of Berar, in the Central Provinces.

In parts of the Dry Zone of Burma an efflorescent deposit consisting largely of salts of sodium, mainly the carbonate is formed on the surface of the soil, and is used locally in the crude condition under the name of *sapaya* or 'soap sand', for washing purposes [1]. The output in 1934 was 6,174 tons valued at Rs. 8,473 (£637) rising in 1935 to 9,525 tons valued at Rs. 10,152 (£763). This production is from the districts of Kyaukse, Meiktila, Myingyan and Sagaing.

There was an increase in the production of steatite from 9,375 tons valued at Rs. 1,70,239 (£12,800) in 1934 to 12,596 tons valued at Rs. 1,91,663 (£14,403) in 1935, principally due to rises in the outputs of the Hazaribagh and Jubbulpore districts. and to other districts in a less degree.

Steatite.

TABLE 47.—*Quantity and value of Steatite produced in India during the years 1934 and 1935.*

—	1934.			1935.		
	Quantity.	Value (£1 = Rs. 13·3).		Quantity.	Value (£1 = Rs 13·3).	
	Tons	Rs.	£	Tons	Rs	£
Bihar and Orissa—						
Hazaribagh	40	300	23	1,225	9,975	750
Mayurbhanj State	1	96	7	23	2,216	167
Seraikela State	..	..	..	30	4,500	338
Singhbhum	244	1,134	86	128	512	38
Central India—						
Bijawar State	40	1,650	124	89	1,974	148
Central Provinces—						
Bhandara	144	2,160	162	500	2,500	188
Jubbulpore	1,723	22,185	1,668	2,321	20,978	1,577
Madras—						
Anantapur	..	..	..	260	2,150	162
Nellore	26	390	29	25	238	18
Salem	220	3,767	283	199	2,206	166
Mysore State	106	635	48	103	567	43
Rajputana—						
Jaipur State	6,671	1,35,750	10,207	6,914	1,40,292	10,548
United Provinces—						
Hamirpur	126	1,397	105	750	3,005	226
Jhansi	34	775	58	29	550	34
TOTAL	**9,375**	*1,70,239*	*12,800*	**12,596**	*1,91,663*	*14,403*

[1] *See* the Quinquennial Review of Mineral Production for 1929-1933.

Sulphate of Ammonia.

Until recently, figures of production of ammonium sulphate as a bye-product at the coking plants of iron and steel works and collieries have been collected only every five years for the quinquennial reviews of mineral production. They prove, however, to be of such general interest that it has been thought desirable to report them annually, and the figures for 1934 and 1935 are shown in Table 48. Values have not been obtained, and ammonium sulphate will not therefore find a place in Table 1. The figures show an increase in production from 11,775 tons in 1934 to 15,398 tons in 1935. The exports for these two years were 2,951 tons and 7,376 tons respectively.

TABLE 48.—*Production of Sulphate of Ammonia in India during the years 1934 and 1935.*

—	1934.	1935.
	Tons	Tons
The Tata Iron and Steel Company, Limited . .	6,028	6,484
The Indian Iron and Steel Company, Limited . .	3,208	6,099
The Burrakur Coal Company, Limited . . .	1,207	1,206
The East Indian Railway Colliery, Giridih . .	219	231
The Bararee Coke Company, Limited . . .	1,113	1,378
TOTAL .	11,775	15,398

IV.—MINERAL CONCESSIONS GRANTED.

TABLE 49.—*Statement of Mineral Concessions granted during the year 1935.*

AJMER-MERWARA.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Ajmer . .	(1) L. Prag Narain C/o The Ice Factory, Ajmer.	Mica and beryl .	P. L. (Renewal).	2·74	19th January 1935.	1 year.
Do. .	(2) Do. .	Beryl and felspar .	P. L. (Renewal).	0·72	5th March 1935.	3 months.
Do. .	(3) L. Gordhanlal Rathi, Nasirabad.	Mica	P. L. (Renewal).	0·60	27th May 1935.	1 year.
Do. .	(4) L. Prag Narain, C/o The Ice Factory, Ajmer.	Mica, felspar, quartz and beryl-ore.	P. L. .	1·72	8th July 1935.	Do.
Do. .	(5) Do. .	Mica, felspar and china clay.	P. L. (Renewal).	0·80	17th August 1935.	Do.
Do. .	(6) Do. .	Felspar	P. L. .	1·88	29th November 1935.	Do.
Do. .	(7) Do. .	Do.	P. L. .	0·76	Do. .	Do.
Do. .	(8) Do. .	Mica, felspar and beryl-ore.	M. L. .	7·00	10th May 1935.	5 years.
Do. .	(9) Messrs. Abdul Ghani & Co., Nasirabad.	Do. .	P. L. .	1·24	16th December 1935.	1 year.
Do. .	(10) Do. .	Mica	P. L. .	6·44	Do. .	Do.
Do. .	(11) Do. .	Mica, felspar and beryl-ore.	M. L. .	5·60	17th April 1935.	5 years.
Do. .	(12) L. Gordhanlal Rathi, Nasirabad.	Mica	P. L. .	0·20	23rd December 1935.	1 year.
Do. .	(13) Do. .	Do.	M. L. .	3·38	17th April 1935.	3 years.
Do. .	(14) Mr. J. K. Soneji of Gujrat, Ajmer.	Mica, felspar and beryl-ore.	P. L. .	0·74	16th December 1935.	1 year.
Beawar .	(15) Do. .	Do. .	P. L. (Renewal).	1·66	13th November 1935.	Do.
Do. .	(16) Quazi Syed Mohamad Niaz Ali, Beawar.	Mica	P. L. .	1·60	9th October 1935.	Do.
Do. .	(17) Do. .	Do.	P. L. (Renewal).	6·56	21st October 1935.	Do.
Kalera Bogla Estate.	(18) Mr. J. K. Soneji of Gujrat, Ajmer.	Do. . . .	M. L. (Renewal).	Whole of Kalera-Bogla Estate.	20th April 1935.	7 years.
Khawas Estate	(19) Mr. Nusserwanji, D. Contractor, Ajmer.	Mica and beryl-ore .	M. L. .	Whole of Khawas Estate.	27th March 1935.	10 years.
Sawar Estate	(20) Do. .	Do. .	M. L. .	Whole of Sawar Estate.	3rd May 1934.	5 years.

P. L.—*Prospecting License.* M. L. —*Mining Lease.*

ASSAM.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
ͅakhimpur .	(21) The Assam Oil Co., Ltd.	Petroleum . .	P. L. .	1,792·0	1st January 1935.	1 year or such time as a mining lease is granted whichever period is less.
Do. .	(22) Do. .	Do. . .	P. L. .	665·6	Do. .	Do.
Do. .	(23) Do. .	Do. . .	P. L. .	3,475·2	31st December 1934.	Do.
Do. .	(24) Do. .	Do. . .	P. L. .	590·7	31st December 1935.	1 year.
ibsagar .	(25) N. N. Roy, Prospecting Syndicate, Ltd.	Limestone . .	M. L. .	250·1	7th February 1935.	15 years.
Do. .	(26) Do. .	Coal	M. L. .	1,684·3	Do. .	30 years.
Do. .	(27) Do. .	Limestone . .	M. L. .	1,684·3	Do. .	15 years.
Do. .	(28) Do. .	Fireclay . .	M. L. .	1,684·3	Do. .	Do.
Do. .	(29) Do. .	China clay . .	M. L. .	1,684·3	Do. .	Do.
ylhet . .	(30) The Burmah Oil Co., Ltd.	Mineral oil . .	P. L. .	9,305·6	1st October 1935.	Up to 5th April 1936.
Do. . .	(31) Do. .	Do. . .	P. L. .	3,161·6	3rd September 1935.	Do.

BIHAR AND ORISSA.

Angul . .	(32) Raja Tricunji .	Red ochre . .	M. L. .	504·20	18th March 1935.	20 years.
Hazaribagh .	(33) Messrs. Chattu Ram Horil Ram Ltd.	Mica	M. L. .	80·00	1st August 1935.	30 years.
Do. .	(34) Rai Bahadur S. K. Sahana.	Do.	M. L. .	127·00	Do. .	Do.
Do. .	(35) Messrs. John Podgar and Company, Ltd.	Do.	M. L. .	40·00	15th October 1935.	Do.
Santal Parganas.	(36) Babu Rameshwar Marwari Darji.	Coal	M. L. .	5·00	1st April 1935.	2 years.
Do. .	(37) Babu Subodh Chandra De.	Do.	M. L. .	2·15	Do. .	Do.
Do. .	(38) Do. .	Do.	M. L. .	1·90	Do. .	Do.
Do. .	(39) Babu Bansi Ram Marwari.	Do.	M. L. .	1·90	Do. .	Do.
Do. .	(40) Babu Ganga Ram Marwari.	Do.	M. L. .	1·82	Do. .	Do.
Do. .	(41) Babu Bansi Ram Marwari.	Do.	M. L. .	0·33	Do. .	Do.
Do. .	(42) Do. .	Do.	M. L. .	0·09	Do. .	Do.
Do. .	(43) Do. .	Do.	M. L. .	5·00	Do. .	Do.

P. L.—*Prospecting License.* M. L.—*Mining Lease.*

BIHAR AND ORISSA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Singhbhum .	(44) Babu N. N. Kumar	Manganese . .	M. L. .	478·40	25th March 1935.	10 years.
Do. .	(45) Babu Mangilal Rungta.	Chromite . .	M. L. .	289·28	19th September 1935.	15 years.
Do. .	(46) Rai Bahadur Ratan Lal Surajmal.	Do. .	P. L. .	1,500·00	25th April 1935.	1 year.
Do. .	(47) Mr. Bibhuti Bhusan Mitra.	Do. . .	P. L. .	1,484·00	8th July 1935.	Do.
Do. .	(48) Babu Mangilal Rungta.	Do. . .	P. L. .	335 00	15th June 1935.	Do.
Do. .	(49) Babu Bhagwan Das Thakur.	Do. . .	P. L. .	215 50	17th August 1935.	Do.
Do. .	(50) Sir Satya Charan Mukharji.	Do. . .	P. L. .	742·40	7th September 1935.	Do.
Do. .	(51) Do. .	Do. . .	P. L. .	160·00	Do. .	Do.
Do. .	(52) Babu B. B. Mitra	Do. . .	P. L. .	720·00	26th August 1935.	Do.
Do. .	(53) Babu Madal Gopal Rungta.	Manganese . .	P. L. .	340·00	26th November 1935.	Do

BOMBAY.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Ahmedabad .	(54) Sultan Chinoy, Esqr.	Mineral oils and natural gas.	P. L. .	9,600	1st January 1935.	1 year
Broach and Panch Mahals.	(55) Shivrajpur Syndicate, Ltd.	Manganese-ore .	M. L. .	18	20th July 1935.	10 years.
Do. .	(56) Do. .	Do. .	M. L. .	26	23rd July 1935.	Do
Kanara .	(57) Messrs. Killick Nixon & Co.	Do. .	P. L. .	203	10th June 1935.	1 year.
Thana . .	(58) Mr. G. P. Sonawala	Bauxite . . .	P. L. .	167	16th November 1935.	To the end of 31st December 1936.

BURMA.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Akyab . .	(59) Messrs. The Indo-Burma Petroleum Co., Ltd.	Natural petroleum (including natural gas).	P. L. (Renewal). .	1,280·0	15th December 1934.	1 year.
Amherst .	(60) Mr. B. R. Fernandez.	All minerals except oil.	P. L. .	2,880·0	20th May 1935.	Do
Do. .	(61) Mr. Saw Eu Hoke	Do. .	P. L. .	211·2	2nd July 1935.	Do.
Do. .	(62) Mr. W. R. Smith	Do. .	P. L. .	640·0	22nd October 1935.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Amherst .	(63) W. R. Smith .	All minerals except oil.	P. L. .	480·0	22nd October 1935.	1 year.
Do. .	(64) Mr. N. Beed .	Antimony . .	P. L. .	480·0	9th September 1935.	Do.
Do. .	(65) Maung Tun Maung	Do. .	P. L. .	1,920·0	3rd October 1935.	Do.
Do. .	(66) U On Pe . .	Tin . . .	M. L. .	640·0	1st June 1935.	30 years.
Bhamo .	(67) Mr. T. Lindsay Willan.	Gold and platinum .	P. L. . (Renewal).	326·4	1st October 1935	1 year.
Do. .	(68) Do. .	Do. .	P. L. . (Renewal).	364·8	9th November 1935.	Do.
Do. .	(69) Mr. D. Kohn .	Gold . . .	P. L. . (Renewal).	51·2	1st October 1935.	Do.
Henzada .	(70) Mr. K. B. Ibrahim	All minerals other than mineral oil.	P. L. .	633·6	23rd December 1935.	Do.
Lower Chindwin.	(71) Messrs. The Indo-Burma Petroleum Co., Ltd	Natural petroleum (including natural gas).	P. L. . (Renewal).	825·6	30th July 1935.	Do.
Do .	(72) Do. .	Do .	P. L. . (Renewal).	1,516·8	24th September 1935.	Do.
Magwe .	(73) Messrs. The Burmah Oil Co., Ltd.	Do. .	P. L. .	72·0	19th August 1935.	2 years.
Meiktila .	(74) Mr. Lim Yoo Kyone.	Antimony . .	P. L. .	985·6	14th November 1935.	1 year.
Mergui .	(75) Mr. V. A. R. Sutherland.	Tin and allied minerals.	P. L. .	121·6	4th June 1935.	Do.
Do. .	(76) Mr. L. C. Khoo .	Do. .	P. L. .	531·2	9th August 1935.	Do.
Do. .	(77) Maung Ba Chin .	Tin . . .	P. L. .	96·0	4th July 1935.	Do.
Do. .	(78) Maung San Dun .	Do. . . .	P. L. .	550·4	12th December 1935.	Do.
Do. .	(79) Mr. Boon Kyet .	Tin and allied minerals.	P. L. .	294·4	1st June 1935.	Do.
Do. .	(80) U Kya Zin . .	Do. .	P. L. .	416·0	20th May 1935.	Do.
Do. .	(81) Maung Chit Pe .	Tin . . .	P. L. .	486·4	8th October 1935.	Do.
Do. .	(82) Mr. Gul Mahamed	Tin and wolfram .	P. L. .	224·0	7th November 1935.	Do.
Do. .	(83) Mr. Eng Tain Leong.	Tin and allied minerals.	P. L. .	19·2	5th July 1935.	Do.
Do. .	(84) Mr. Tan Shu En .	Tin . . .	P. L. .	320·0	3rd July 1935.	Do.
Do. .	(85) Mr. Saw Lein Lee	Tin and allied minerals.	P. L. .	44·8	5th July 1935.	Do.
Do. .	(86) Mr M. Haniff .	Tin and wolfram .	P. L. .	691·2	29th August 1935.	Do.
Do. .	(87) Mr. Tan Teik Aik	Do. .	P. L. .	556·8	27th September 1935.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Mergui .	(88) Mr. Chey Shark .	Tin-ore . . .	P. L. .	480·0	5th June 1935.	1 year.
Do. .	(89) Mr. En Gwan Kyin	Do. . . .	P. L. .	492·8	6th September 1935.	Do.
Do. .	(90) Mr. Jamal Oomer	Do. . . .	P. L. .	544·0	28th May 1935.	Do.
Do. .	(91) U Kya Zin . .	Tin and allied minerals.	P. L .	601·6	29th May 1935.	Do.
Do. .	(92) Mr. Tan Teik Aik	Tin and wolfram .	P. L. .	147·2	4th July 1935	Do.
Do. .	(93) Mr. Eng. Tain Leong.	Do. . .	P. L. .	83·2	11th June 1935.	Do.
Do. .	(94) Saw Maung Po .	Tin . . .	P. L. .	640·0	12th December 1935.	Do.
Do. .	(95) Mr. G. H. Hand .	Tin and wolfram .	P. L. .	256·0	16th August 1935.	Do.
Do. .	(96) Mr. Eng. Tain Leong.	Do. . .	P. L. .	1,248·0	14th December 1935.	Do
Do. .	(97) Mr. M. Haniff .	Wolfram, tin and other allied metals.	P. L. .	480·0	4th July 1935.	Do.
Do .	(98) Messrs The Tavoy Prospectors Ltd.	All minerals other than oil.	P. L.	569·6	11th June 1935	Do.
Do. .	(99) Mr. L. R. Beale .	Tin and wolfram	P. L.* .	620·8	26th September 1935.	Do.
Do. .	(100) Mr. Tan Teik Aik.	Do. . .	P. L. .	556·8	4th September 1935.	Do.
Do. .	(101) Ma Tin . .	Do. . .	P. L. .	422·4	30th October 1935.	Do.
Do. .	(102) Mr. E. Kyin Hlaing.	Tin . . .	P. L. .	377·6	28th September 1935.	Do.
Do. .	(103) Mr. F. Wah Yu	Tin and wolfram .	P. L. .	556·8	30th October 1935.	Do.
Do. .	(104) Mr. Ah Yee .	Do. . .	P. L. .	480·0	9th August 1935.	Do.
Do. .	(105) Maung Sein Chi .	Tin-ore . . .	P. L. .	172·8	5th July 1935.	Do.
Do. .	(106) Mr. Ooi Kwe Ya	Tin and wolfram .	P. L. .	512·0	8th August 1935.	Do.
Do. .	(107) Mr. Tan Shu En	Tin-ore . . .	P. L. .	480·0	30th September 1935.	Do.
Do. .	(108) Mr. Jamal Oomer	Do. . . .	P. L .	102·4	28th May 1935.	Do.
Do. .	(109) Maung Hlaing Pu	Tin and wolfram .	P. L. .	467·2	23rd October 1935.	Do
Do. .	(110) Mr. Eng Taing Leong.	Tin-ore . . .	P. L. .	185·6	18th October 1935.	Do.

P. L.—*Prospecting License.* M. L.—*Mining Lease.*

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Mergui .	(111) Mr. M. Haniff .	Tin and wolfram .	P. L. .	940·8	14th August 1935.	1 year.
Do. .	(112) Mr. P. B. O. Watson.	Do. . .	P. L. .	806·4	26th September 1935.	Do.
Do. .	(113) Maung Sein Shen	Do. . .	P. L. .	262·4	4th October 1935.	Do.
Do. .	(114) Mr. Eng Tain Leong.	Tin-ore . . .	P. L. .	704·0	19th August 1935.	Do.
Do. .	(115) Maung Hlaing Pu	Tin and wolfram .	P. L. .	275·2	23rd October 1935.	Do
Do. .	(116) Mr. Jamal Oomar	Tin ore . . .	P. L. .	384·0	5th September 1935.	Do.
Do. .	(117) Mr. F. Wah Yu	Tin and wolfram .	P. L. .	140·8	12th August 1935.	Do.
Do. .	(118) Mr. A. D. Vaid .	Tin-ore . .	P. L. .	377·6	19th November 1935.	Do.
Do. .	(119) Maung Nyan Thein.	Do .	P. L. .	179·2	17th December 1935.	Do.
Do. .	(120) Maung Kyin Haing.	Do. . . .	P. L. .	198·4	27th September 1935.	Do.
Do. .	(121) Mr. Abu Khoon	Do. . .	M. L. .	172·8	1st May 1935.	30 years.
Do. .	(122) U San Dun .	Tin and wolfram .	M. L. .	211·2	Do. .	1 year.
Do. .	(123) Mr. A. S. Mahomed.	Do. .	M. L. .	640·0	1st January 1935.	Do.
Do. .	(124) Mr. Udhandar .	Do. . .	M. L. .	1,017·6	1st August 1935.	Do.
Do. .	(125) Do. .	Do. . .	M. L .	211·2	1st July 1935.	Do.
Do. .	(126) Mr. E. Ahmed .	Do. . .	M. L. .	275·2	1st May 1935.	Do.
Do. .	(127) Mr. Yew Shwe Ni	Do. .	M. L. .	211 2	1st September 1935.	Do.
Do. .	(128) Messrs. The Malayan and General Trust (1933), Ltd.	Do. .	M. L. .	998·4	1st July 1935.	Do.
Do. .	(129) Mr. Eng. Tain Leong.	Tin . .	M. L. .	179·2	15th March 1935.	Do.
Do. .	(130) Mr. Im Sit Yan .	Tin and wolfram .	M. L. .	134·4	1st April 1935.	Do.
Do. .	(131) Maung Hlaing Pu	Do. . .	M. L. .	198·4	1st November 1935.	Do.
Do. .	(132) Mr. A. D. Vaid .	Tin and allied minerals.	P. L. (Renewal). .	326·4	19th January 1935.	Do.
Do. .	(133) Mr. Ooi Boon Kyat.	Tin-ore . . .	P. L. (Renewal). .	262·4	3rd January 1935.	Do.
Do. .	(134) Mr. Tan Siw Shin	Tin and allied minerals.	P. L. (Renewal). .	204·8	22nd January 1935.	Do.
Do. .	(135) Mr. Saw Lein Lee	Do. .	P. L. (Renewal). .	121 6	29th January 1935.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

BURMA—*contd.*

District.	Grantee.	Mineral	Nature of grant	Area in acres.	Date of commencement.	Term.
Mergui .	(136) U E. Gyi . .	Tin-ore, wolfram and allied minerals	P. L. . (Renewal).	153 6	15th January 1935	1 year.
Do. .	(137) U San Dun .	Tin	P. L. (Renewal).	128 0	12th January 1935	Do.
Do. .	(138) Ma Tin . .	Tin and allied minerals.	P. L. . (Renewal).	608 0	12th January 1935.	Do.
Do. .	(139) Mr. Tan Teik Aik	Tin-ore . . .	P. L. . (Renewal).	499 2	16th January 1935.	Do.
Do. .	(140) Mr. In Sit Yan .	Tin and allied minerals.	P. L. . (Renewal)	204 8	19th February 1935	Do.
Do. .	(141) Mr. Chey Shark .	Tin, wolfram and other allied metals.	P. L. . (Renewal).	249·6	16th February 1935.	Do.
Do. .	(142) Mr. Eng Tain Leong.	Tin-ore	P. L. . (Renewal).	224 0	Do. .	Do.
Do. .	(143) Mr. Gul Mahamed.	Tin and wolfram .	P. L. . (Renewal).	371 2	7th February 1935.	Do.
Do. .	(144) Do. .	Tin and associated minerals.	P. L. . (Renewal).	486·4	6th February 1935.	Do.
Do. .	(145) Mr. A. D. Vaid .	Tin and allied minerals	P. L. . (Renewal).	428 8	28th February 1935.	Do.
Do. .	(146) U Kya Zin .	Do. . .	P. L. . (Renewal).	217 6	6th February 1935.	Do.
Do. .	(147) Mr. Leong Foke Hye.	Tin-ore	P. L. . (Renewal).	428 8	19th February 1935.	Do.
Do. .	(148) Mr. Ah Khoon .	Tin and allied minerals.	P. L. . (Renewal)	428 8	Do .	Do.
Do. .	(149) Mr. Tan Teik Aik	Tin-ore . .	P. L . (Renewal).	428 8	15th February 1935	Do.
Do. .	(150) Mr. A. S. Mahmed	Tin and other allied metals.	P. L. . (Renewal).	544·0	Do. .	Do.
Do. .	(151) Mr. A. E. Ahmed	Wolfram, tin and other allied metals.	P. L. . (Renewal).	678·4	9th March 1935.	Do.
Do. .	(152) Mr. Leong Foke Hye.	Tin and allied minerals.	P. L . (Renewal).	411 6	8th March 1935	Do.
Do. .	(153) Mr. Ooi Boon Kyet.	Do. .	P. L . (Renewal).	147·2	9th March 1935.	Do.
Do. .	(154) Mr. S. E. Mayat	Tin-ore . . .	P. L. . (Renewal).	57 6	Do. .	Do.
Do. .	(155) Mr. Lim Oo Ghine.	Tin and other allied metals.	P. L. . (Renewal).	262·4	Do. .	Do.
Do. .	(156) Mr. E. Kyin Hlaing.	Tin and wolfram .	P. L. . (Renewal).	345 6	Do. .	Do.
Do. .	(157) Mr. F. Wah Yu .	Tin-ore . . .	P. L. . (Renewal).	268 8	10th March 1935	Do.
Do. .	(158) Mr. Maung Kyin Hlaing.	Do. . . .	P. L. . (Renewal)	800·0	Do. .	Do.

P. L.=*Prospecting License.*

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Mergui .	(159) Mr. Tan Teik Aik	Tin-ore . . .	P. L. (Renewal).	198·4	9th March 1935.	1 year.
Do. .	(160) Do. .	Do. . . .	P. L. (Renewal).	185·6	27th March 1935.	Do.
Do. .	(161) Maung Chit Pe .	Do. . . .	P. L. (Renewal).	595·2	10th March 1935.	Do.
Do. .	(162) Mr. Chey Shark .	Wolfram . .	P. L. (Renewal).	1,158·4	24th April 1935.	Do.
Do. .	(163) Maung Sein Shan	Tin and allied minerals.	P. L. (Renewal).	499·2	20th March 1935.	Do.
Do. .	(164) Saw Maung Po .	Tin-ore . . .	P. L. (Renewal).	268·8	21st March 1935.	Do.
Do. .	(165) Mr. Ooi Kwee Ya	Tin and allied minerals.	P. L. (Renewal).	345·6	29th March 1935.	Do.
Do. .	(166) Mr. Gul Mahamed.	Tin and associated minerals.	P. L. (Renewal).	377·6	5th April 1935.	Do.
Do. .	(167) Mr Shazada Khan.	Tin and allied minerals.	P. L. (Renewal).	224·0	17th April 1935.	Do.
Do. .	(168) Do. .	Tin and associated minerals.	P. L. (Renewal).	384·0	Do. .	Do.
Do. .	(169) Maung Sein Shan	Tin-ore . . .	P. L. (Renewal).	467·2	Do. .	Do.
Do. .	(170) Saw Maung Po .	Do. . . .	P. L. (Renewal).	198 4	Do. .	Do.
Do. .	(171) Ma Tin . .	Do. . . .	P. L. (Renewal).	172 8	21st April 1935.	Do.
Do. .	(172) Saw Maung Po .	Do. . . .	P. L. (Renewal).	896·0	17th April 1935.	Do.
Do. .	(173) Mr. Eu Gwan Kyin.	Do. . . .	P. L. (Renewal).	96·0	Do. .	Do.
Do. .	(174) Mr. Tan Eik Bhee.	Tin and allied minerals.	P. L. (Renewal).	409·6	4th May 1935.	Do.
Do. .	(175) Saw Maung Po .	Tin-ore . . .	P. L. (Renewal).	243·2	17th April 1935.	Do.
Do. .	(176) Mr. In Sit Yan .	Tin and other minerals.	P. L. (Renewal).	294·4	13th May 1935.	Do.
Do. .	(177) U Kya Zin .	Tin and allied minerals.	P. L. (Renewal).	358 4	25th April 1935.	Do.
Do. .	(178) Mr. W. King Ling	Do. . .	P. L. (Renewal).	83·2	3rd May 1935.	Do.
Do. .	(179) Mr. Ah Khoon .	All minerals except mineral oil.	P. L. (Renewal).	620·8	19th May 1935.	Do.
Do. .	(180) Mr. Ah Yee .	Wolfram . .	P. L. (Renewal).	160·0	22nd May 1935.	Do.
Do. .	(181) Mr Jamal Oomar	Tin-ore . . .	P. L. (Renewal).	57·6	1st May 1935.	Do.

P. L.=*Prospecting License.*

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Mergui .	(182) Mr. Tan Eik Kun	Tin and allied minerals.	P. L. (Renewal).	384·0	10th May 1935.	1 year.
Do. .	(183) Mr. Jamal Oomar	Wolfram . .	P. L. (Renewal).	448 0	9th May 1935.	Do.
Do. .	(184) Mr. Tan Teik Aik.	Tin-ore . . .	P. L. (Renewal)	217·6	15th May 1935.	Do.
Do. .	(185) Mr. Shazada Khan	Do. . . .	P. L. (Renewal)	556·8	17th May 1935.	Do.
Do. .	(186) Ma Hta Shwe .	Do . . .	P. L. (Renewal)	307 2	23rd June 1935.	Do.
Do. .	(187) Do. .	Do. . . .	P. L. (Renewal).	396 8	26th June 1935.	Do.
Do .	(188) Mr. Tan Shu Eu	Tin and associated minerals.	P. L (Renewal)	281 6	Do. .	Do.
Do. .	(189) Ma Tin . .	Do. . . .	P. L (Renewal).	102·0	28th June 1935.	Do.
Do. .	(190) Mr. Ten Teik Gwan.	Wolfram . .	P. L. (Renewal).	121 6	2nd July 1935.	Do.
Do. .	(191) Mr. A. S. Mahomed.	Wolfram and other associated minerals.	P. L. (Renewal)	748 8	1st August 1935.	Do.
Do. .	(192) Mr. Tan Boon Hein.	Tin-ore . . .	P. L. (Renewal)	140·8	21th August 1935.	Do.
Do. .	(193) U Kya Zin .	Wolfram . .	P. L. (Renewal).	83·2	25th August 1935.	Do.
Do. .	(194) Mr. Tan Teik Aik	Tin-ore . . .	P. L. (Renewal)	876·8	22nd August 1935.	Do.
Do. .	(195) Mr Leong Ah Chan.	Wolfram .	P. L. (Renewal).	307 2	8th September 1935.	Do.
Do. .	(196) Mr John T Doupe	Tin and all other minerals	P. L (Renewal).	108·8	6th September 1935.	Do.
Do. .	(197) Mr Ah Yee	Tin-ore . . .	P. L. (Renewal).	352 0	20th October 1935.	Do.
Do. .	(198) Ma Hta Shwe .	All minerals except oil.	P. L (Renewal).	345·6	25th September 1935.	Do.
Do. .	(199) Mr. Gul Mahamed	Wolfram . .	P. L. (Renewal).	505·6	21st September 1935.	Do.
Do. .	(200) Mr. L. R. Beale	Tin and associated minerals	P. L. (Renewal).	217·6	16th November 1935.	Do.
Do. .	(201) Mr. A. Helleman	Tin and allied minerals.	P. L. (Renewal).	76·8	17th November 1935.	Do.
Minbu . .	(202) Messrs. The Burmah Oil Co., Ltd.	Natural petroleum (including natural gas).	P. L. .	76·8	10th May 1935.	2 years.
Myingyan .	(203) Messrs. The British Burmah Petroleum Co., Ltd.	Do. .	P. L. .	640 0	30th August 1935.	1 year.

P. L. = *Prospecting License.*

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Myingyan .	(204) Messrs. The British Burma Petroleum Co., Ltd.	Natural petroleum (including natural gas)	P. L. .	2,442·2	10th January 1935.	2 years.
Do. .	(205) Messrs The Burmah Oil Co., Ltd.	Do .	P. L .	5,235 2	30th August 1935.	Do.
Myitkyina .	(206) Mr. C W. Chater	All minerals except oil	P. L. .	1,216·0	11th May 1935.	1 year.
Do .	(207) Dr. A. W. G. Bleeck	Gold and platinum	P. L. .	1,920 0	7th February 1935.	Do.
Do .	(208) Mr W. R Smith	Do. .	P. L. .	3 584 0	10th May 1935.	Do.
Do. .	(209) Dr A. W. G Bleeck.	Do. .	P. L. .	1,280 0	20th July 1935.	Do.
Do .	(210) Mr. George E. Myers.	Gold . .	P L. .	640·0	Do. .	Do.
Do .	(211) Do. .	Do. . . .	P. L .	640·0	Do. .	Do.
Do .	(212) Do. .	Do. . .	P. L. .	640 0	Do.	Do.
Do .	(213) Do .	Do. . .	P. L. .	640·0	Do. .	Do
Northern Shan States	(214) Mr. A R. Oberlander.	Antimony . .	P L. .	160 0	30th March 1935.	Do
Do. .	(215) Messrs The Burma Corporation, Ltd.	Iron-ore . .	P. L. .	3 8	27th September 1935.	Do.
Do. .	(216) Do. .	Do. . . .	P. L (Renewal).	720·0	4th July 1935	Do.
Pakokku .	(217) Messrs The Burmah Oil Co , Ltd	Natural petroleum (including natural gas)	P L. . (Renewal)	778 2	23rd December 1934.	Do.
Do. .	(218) Do. .	Do. .	P L . (Renewal).	160 0	14th December 1935	Do.
Salween .	(219) Maung Nyun U	All minerals except mineral oil, tin and wolfram combined.	P L. .	518 4	25th January 1935	Do.
Do. .	(220) Mr. G. E. Myers.	Gold . . .	P L . (Renewal).	640·0	1st June 1935.	Do.
Do. .	(221) Do. .	Do. . . .	P. L. . (Renewal).	640·0	Do. .	Do.
Do. .	(222) Do. .	Do. . . .	P. L . (Renewal).	1,280 0	Do. .	Do.
Do. .	(223) Do .	Do. . . .	P. L. . (Renewal).	640·0	Do. .	Do.
Do. .	(224) Mr W. R Smith	All minerals except oil, tin and tin and wolfram combined.	P. L. . (Renewal).	672·0	1st May 1935.	Do.
Do. .	(225) Mr G. E. Myers	Gold . . .	P. L. . (Renewal).	640·0	1st June 1935.	Do.
Do. .	(226) Daw Hla Shwe .	All minerals except mineral oil	P. L. . (Renewal)	640·0	1st September 1935.	Do.

P. L.=*Prospecting License.*

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term
Shwebo .	(227) U Maung Gyee .	Gold or other minerals.	P. L. .	236·8	17th September 1935	1 year.
Do .	(228) Messrs. The Indo-Burma Petroleum Co., Ltd.	Natural petroleum (including natural gas).	P. L. (Renewal) .	2,547·2	12th March 1935	Do
Do. .	(229) Do. .	Do. .	P. L. (Renewal).	5,440·0	14th August 1935.	Do.
Southern Shan States.	(230) Mr. Saw Lein Lee	Wolfram, lead and antimony.	P. L. .	1,280·0	26th March 1935.	Do.
Do. .	(231) Do. .	All minerals except tin.	P. L. .	1,280·0	21st March 1935.	Do.
Do. .	(232) Mr. A. Gasper .	Do. .	P. L. .	960·0	2nd March 1935.	Do.
Do. .	(233) Mr S. E. Mayet	Do .	P. L. .	1,280·0	19th January 1935	Do.
Do. .	(234) Mr. Chey Ah Hee	Do. .	P. L. .	320·0	29th August 1935	Do.
Do. .	(235) Mr L Yone Kyat Chin	Do .	P. L. .	800·0	22nd June 1935.	Do.
Do .	(236) Do .	Do. .	P. L. .	1,280·0	26th July 1935.	Do.
Do .	(237) Mr. L Ah Ton .	Do .	P. L. (Renewal) .	640·0	11th August 1935.	Do.
Tavoy . .	(238) Mr C. T. S. Ransom.	Wolfram . .	P. L. .	352·0	17th December 1934.	Do.
Do .	(239) Messrs Eu Pola Brothers.	Do. .	P. L. .	64·0	4th January 1935	Do.
Do. .	(240) Do .	Do. . .	P. L. .	192·0	10th January 1935	Do.
Do. .	(241) Mr W. Kin Lung	Do. . .	P. L. .	396·8	18th January 1935	Do.
Do. .	(242) Mr. Eu Kyaung Nga	Do. . .	P. L. .	640·0	22nd January 1935.	Do.
Do. .	(243) Mr. R. C. N. Twite.	Do. . . .	P. L. .	14·7	31st January 1935	Do.
Do .	(244) Do. .	Do. . . .	P. L. .	70·4	Do. .	Do.
Do. .	(245) Dr. Eu Tha Zwan	Do. . . .	P. L. .	428·8	1st February 1935.	Do.
Do. .	(246) U Aye Pe .	Do. . . .	P. L. .	211·2	2nd February 1935.	Do.
Do. .	(247) Mr. Chan Kee .	Do . . .	P. L. .	57·6	8th February 1935.	Do.
Do. .	(248) Messrs. Eu Pola Brothers.	Do. . . .	P. L. .	192·0	11th February 1935.	Do.
Do. .	(249) Mr. Yoe Toe Bwa	Do. . . .	P. L. .	153·6	Do. .	Do.
Do. .	(250) Mr. Phuman Singh.	Do. . . .	P. L. .	339·2	26th February 1935	Do.

P. L.=*Prospecting License.*

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Tavoy	(251) Mr. R. C. N. Twite.	Wolfram	P. L.	57·6	5th March 1935.	1 year.
Do.	(252) Messrs. Eu Pola Brothers.	Do.	P. L.	326·4	15th March 1935.	Do.
Do.	(253) Mr. Shazada Khan.	Do.	P. L.	198·4	3rd April 1935.	Do.
Do.	(254) Saw Maung Po	Do.	P. L.	25·6	18th April 1935.	Do.
Do.	(255) Dr. Eu Tha Zwan	Do.	P. L.	147·2	24th April 1935.	Do.
Do.	(256) Messrs. Eu Pola Brothers	Do.	P. L.	320·0	26th June 1935.	Do.
Do.	(257) Mr. Chew Whee Shain.	Do.	P. L.	57·6	24th June 1935.	Do.
Do.	(258) Messrs. Eu Pola Brothers.	Do.	P. L.	192·0	5th April 1935.	Do.
Do.	(259) Mr. Kim Swe	Tin and allied minerals.	P. L.	377·6	1st July 1935.	Do.
Do.	(260) U Kyaing	Wolfram	P. L.	166·4	24th July 1935.	Do.
Do.	(261) Mr. Lim Twa Kee	Do.	P. L.	275·2	8th August 1935.	Do.
Do.	(262) Mr Yoe Kyi Han	All minerals except oil	P. L.	544 0	24th August 1935.	Do.
Do.	(263) Mr. Phuman Singh.	Do.	P. L	640·0	Do.	Do.
Do.	(264) U Shwe Myoo	Wolfram	P. L.	381 0	13th September 1935.	Do.
Do.	(265) U Ba Hlaing	All minerals except oil.	P. L	128·0	7th October 1935.	Do.
Do.	(266) Mr. Phuman Singh.	Do.	P. L.	556 8	8th October 1935.	Do.
Do.	(267) Mr. Eu Kyaung Nga.	Do.	P. L.	102 4	19th October 1935.	Do.
Do.	(268) Daw Thin Myaing	Do.	P. L.	595·2	25th October 1935.	Do.
Do.	(269) Mr. Yoe Kyi Han	Do.	P. L.	499·2	Do.	Do.
Do.	(270) U Maung Maung Latt.	Do.	P. L.	640·0	4th November 1935.	Do.
Do.	(271) Mr. Yoe Toe Bwa	Do.	P. L.	832·0	7th November 1935.	Do.
Do.	(272) Mr. Lim Toe Yin	Do.	P. L.	960·0	15th November 1935.	Do.
Do.	(273) Mr. R. C. N. Twite	Do.	P. L	556·8	28th November 1935.	Do.
Do.	(274) Mr. V. A. R Sutherland.	Do.	P L.	147·2	4th December 1935.	Do.

P. L.=*Prospecting License.*

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Tavoy . .	(275) Mr. Shazada Khan.	Wolfram . .	P. L. .	1,280·0	21st December 1935.	1 year.
Do. . .	(276) U Ba Lay . .	Do. . .	P. L. .	320·0	11th November 1935.	Do.
Do. . .	(277) Saw Maung Po .	Do. . .	P. L. .	332·8	15th November 1935.	Do.
Do. . .	(278) Mr. Tan Pe Thin	Do. . .	P. L. .	320·0	18th November 1935.	Do.
Do. . .	(279) Do. .	Do. . .	P. L. .	704 0	30th November 1935.	Do.
Do. . .	(280) Do. .	Do. . .	P. L. .	198·4	4th December 1935.	Do.
Do. . .	(281) Mr R. C. N. Twite.	All minerals except oil.	P. L. .	320·0	30th October 1935.	Do.
Do . .	(282) Mr. Quah Cheng Guan.	Tin, wolfram and allied minerals.	M. L. .	236 8	15th August 1935.	30 years.
Do. . .	(283) Mr. C. Soo Don .	Tin and allied minerals.	M. L. .	147 2	1st December 1935.	Do.
Do .	(284) Mr. Quah Hun Cheong.	Tin, wolfram and allied minerals	M L. .	320 0	15th October 1935.	Do.
Do .	(285) U Ohn Nyun .	Tin and wolfram .	M L .	96·0	1st December 1935.	Do.
Do .	(286) Do. .	Do .	M L	198·4	Do. .	Do.
Do	(287) Mr Quah Hun Cheong	Tin, wolfram and allied minerals	M L .	268 8	1st November 1935.	Do.
Do . .	(288) Do .	Do .	M L .	1,574·4	1st February 1935.	Do.
Do .	(289) Messrs. The Tavoy Tin Dredging Corporation, Ltd	All minerals except petroleum and precious stones	M L.	249 6	3rd February 1935	15 years.
Do .	(290) Mr Eu Kyaung Nga.	All minerals except oil	P L . (Renewal)	1,280 0	7th September 1935.	1 year.
Do .	(291) U Maung Maung Latt	Do .	P L. . (Renewal)	1,152 0	3rd September 1935	Do
Do. .	(292) Mr Eu Kyaung Nga.	Do. .	P L . (Renewal)	1,280 0	13th October 1935	Do.
Do. . .	(293) Mr. Shazada Khan	Do. .	P. L. . (Renewal).	640 0	21st December 1935.	Do.
Do. . .	(294) Mr. Eu Kyaung Nga.	Do. .	P. L . (Renewal)	1,280 0	6th September 1935	Do
Do. . .	(295) Mr. C. T. S. Ransom.	Do. .	P. L . (Renewal).	640·0	30th November 1935.	Do.
Do. . .	(296) The Mintha Tin Mine Syndicate.	Do. .	P. L. . (Renewal).	640·0	1st March 1935.	Do.
Do. . .	(297) Mr. Teh Lu Pe .	Do .	P. L. . (Renewal).	480 0	27th February 1935.	Do.

P. L.—*Prospecting License.* M. L.—*Mining Lease.*

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Tavoy . .	(298) Mr. H. G. Gregson	All minerals except oil.	P. L. (Renewal).	44·8	2nd April 1935.	1 year.
Do. . .	(299) Mr. Teh Lu Pe	Do. .	P. L. (Renewal).	128·0	18th April 1935.	Do.
Do. . .	(300) Mr. Yeo Kyi Han	Do. .	P. L. (Renewal).	428·8	9th June 1935.	Do.
Do. . .	(301) Do. .	Do. .	P. L. (Renewal).	76·8	6th September 1935.	Do.
Do. . .	(302) Mr. Chan Keo .	Do. .	P. L. (Renewal).	435·2	20th May 1935.	Do.
Do. . .	(303) Mr. Teh Lu Pe	Do. .	P. L. (Renewal).	1,280·0	4th June 1935.	Do.
Do. . .	(304) Mr. C. Soo Don .	Do. .	P. L. (Renewal).	313·6	15th June 1935.	Do.
Do. . .	(305) Mr V. A. Ross Sutherland.	Do. .	P. L. (Renewal).	115·2	5th June 1935.	Do.
Do. . .	(306) Eu Kyaung Nga-Daw Thi Syndicate.	Do. .	P. L. (Renewal).	960·0	22nd May 1935.	Do.
Do. . .	(307) Do. .	Do. .	P. L. (Renewal).	832·0	27th July 1935.	Do.
Do. . .	(308) Mr. Chan Keo .	Do. .	P. L. (Renewal).	512·0	24th July 1935.	6 months.
Do. . .	(309) Mr. Eu Kyaung Nga.	Do. .	P. L. (Renewal).	204·8	14th July 1935.	1 year.
Do. . .	(310) U Aye Pe . .	Wolfram . .	P. L. (Renewal).	499·2	13th July 1935.	Do.
Do. . .	(311) U Ba Hlaing .	All minerals except oil.	P. L. (Renewal).	704·0	7th October 1935.	Do.
Do. . .	(312) Mr Teh Lu Pe	Do. .	P. L. (Renewal).	960·0	18th August 1935.	Do.
Do. . .	(313) U Saw Pe . .	Do. .	P. L. (Renewal).	1,664·0	3rd September 1935.	Do.
Do. . .	(314) Mr. Shazada Khan.	Wolfram . .	P. L. (Renewal).	1,280·0	24th September 1935.	Do.
Do. . .	(315) Mr. G. A. Tudee	All minerals except oil.	P. L. (Renewal).	499·2	7th September 1935.	Do.
Do. . .	(316) Mr. C. Soo Don .	Wolfram . .	P. L. (Renewal).	275·2	Do.	Do.
Do. . .	(317) Mr. H. G. Gregson	Tin and wolfram .	P. L. (Renewal).	140·8	28th April 1935.	Do.
Do. . .	(318) U Saw Pe . .	All minerals except oil.	P. L. (Renewal).	704·0	10th September 1935.	Do.
Do. . .	(319) Mr. G. A. Tudee	Do. .	P. L. (Renewal).	1,280·0	18th August 1935.	Do.
Thaton. .	(320) Mr. T. M. Khan	All minerals except oil and tin.	P. L. .	1,280·0	9th October 1935.	Do.

P. L. = *Prospecting License.*

BURMA—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term
Thaton .	(321) Mr. W. R. Smith	All minerals except oil, tin and wolfram.	P. L. . (Renewal).	480·0	6th March 1935	1 year.
Do. .	(322) Daw Hnin Mya	All minerals except tin, oil and natural gas.	P. L. . (Renewal).	320·0	22nd November 1935.	Do.
Thayetmyo .	(323) Messrs. The Burmah Oil Co., Ltd.	Natural petroleum (including natural gas).	P. L. .	1,984·0	16th November 1934.	2 years.
Do. .	(324) Messrs. The Indo-Burma Petroleum Co., Ltd.	Do. .	P. L. .	320·0	9th February 1935.	Do.
Do. .	(325) Messrs. The Burmah Oil Co., Ltd.	Do. .	P. L. .	2,457·6	30th June 1935.	1 year.
Do. .	(326) Mr. W. R. Smith	Do. .	P. L. .	108·8	16th August 1934.	Do.
Do. .	(327) Messrs. The Burmah Oil Co., Ltd.	Do. .	P. L. . (Renewal).	1,780·0	7th January 1935.	Do.
Do. .	(328) Do. .	Do. .	P. L. . (Renewal).	2,240·0	23rd March 1935.	Do.
Toungoo .	(329) Saw Maung Po .	Gold	P. L. .	6,048·0	21st January 1935.	Do.
Do. .	(330) U San Dun .	Do	P. L. .	960·0	14th December 1935.	Do.
Upper Chindwin.	(331) Messrs. The Indo-Burma Petroleum Co., Ltd.	Natural petroleum (including natural gas).	P. L. .	640·0	6th October 1934.	2 years.
Do. .	(332) Messrs. Fairweather Richards & Co., Ltd.	Coal	P. L. .	704·0	11th March 1935.	1 year.
Do. .	(333) Messrs. The Indo-Burma Petroleum Co., Ltd.	Natural petroleum (including natural gas).	P. L. .	1,280·0	2nd August 1935	2 years.
Do. .	(334) Do. .	Do. .	P. L. . (Renewal).	1,410·0	17th March 1935.	1 year.
Do. .	(335) Messrs. The Burmah Oil Co., Ltd.	Do. .	P. L. . (Renewal).	8,320·0	25th June 1935.	Do.
Yamethin .	(336) Mr. Saw Lein Lee	All minerals except oil.	P. L. .	1,600·0	13th May 1935.	Do.
Do. .	(337) U. E. Gyi . .	Tin and allied minerals.	P. L. .	960·0	30th August 1935.	Do.
Do. .	(338) Mr. C. Hock Sheiu	All minerals except oil.	P. L. .	640·0	11th January 1935.	Do.
Do. .	(339) Mr. J. W. Ryan	All minerals except precious stones.	P. L. .	1,152·0	10th August 1935	Do.
Do. .	(340) Mr. Ah Ton .	All minerals except oil and tin.	P. L. .	640·0	27th January 1935.	Do.
Do. .	(341) Mr. A. Gasper .	All minerals except tin.	P. L. .	1,913·6	12th January 1935.	Do.

P. L.=*Prospecting License.*

BURMA—*concld.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Yamethin .	(342) Mr. Syed Ebrahim	All minerals except mineral oil.	P. L. .	640·0	18th February 1935.	1 year.
Do. .	(343) Mr. W. H. Heard White.	All minerals except tin.	P. L. .	1,280·0	14th February 1935.	Do.
Do. .	(344) Mr. L. K. Ngaw	Do. .	P. L. .	1,280·0	2nd May 1935.	Do.
Do. .	(345) Do. .	All minerals except tin and oil.	P. L. .	640·0	Do. .	Do.
Do. .	(346) Mr. W. H. Heard White.	All minerals except oil.	P. L. .	1,344·0	10th January 1935.	Do.
Do. .	(347) Mr. D. Snadden	Do. .	P. L. .	1,280·0	8th January 1935.	Do.
Do. .	(348) Do. .	Do. .	P. L. .	640·0	15th January 1935.	Do.
Do. .	(349) Do. .	Do. .	P. L. .	1,280·0	14th February 1935.	Do.
Do. .	(350) U. Maung Gyee	Do. .	P. L. .	627·2	13th August 1935.	Do.
Do. .	(351) Mr. W. H. Heard White.	Do. .	P. L. .	640 0	31st May 1935.	Do.
Do. .	(352) Mr. D Snadden	Do. .	P. L. .	640·0	10th April 1935.	Do.
Do .	(353) Mr. B. Ghosh .	Do. .	P. L. .	1,280·0	3rd July 1935.	Do.
Do. .	(354) Do. .	Do. .	P L. .	1,036 8	10th September 1935.	Do
Do. .	(355) Mr L. Y Chant Chin.	Do. .	P L. .	1,830 4	17th September 1935.	Do.
Do.	(356) Mr. B. Ghosh .	Do. .	P. L. .	1,510·4	18th October 1935.	Do.
Do .	(357) Mr. D. Snadden	Do. .	P. L. .	320 0	12th November 1935	Do.
Do. .	(358) Mr. S Ebrahim .	Do. .	P. L. .	1,280 0	1st August 1935.	Do
Do. .	(359) Mr. S. B. Banerji	Do. .	P. L. .	1,280·0	11th June 1935.	Do.
Do. .	(360) U. Maung Gyee .	Do .	P. L. .	640 0	29th June 1935.	Do.
Do. .	(361) Mr. Saw Lein Lee	Do. .	P. L. .	480·0	19th August 1935.	Do.
Do. .	(362) Mr. H. R. H. Abdulla.	All minerals except oil and tin.	P. L. .	1,696·0	30th November 1935.	Do.
Do. .	(363) Mr. Hajee Abdul Malik.	Do .	P. L. .	320·0	18th November 1935.	Do.
Do. .	(364) Mr. L. K. Ngaw	Wolfram . .	P. L. .	281·6	18th December 1935.	Do.
Do. .	(365) Do .	Do. . .	P. L. .	838·4	17th May 1935.	Do.

P. L.—*Prospecting License.*

CENTRAL PROVINCES.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Balaghat .	(366) Rai Bahadur Seth Gowardhandas of Tumsar.	Manganese-ore .	M. L. .	363	15th February 1935.	30 years.
Do. .	(367) Do. .	Do. . .	M. L. .	59	21st January 1935.	Do.
Do. .	(368) Messrs B. P. Byramji and Company, Nagpur.	Do. . .	M. L. .	20	2nd August 1934.	5 years.
Do. .	(369) Mr. Amritlal P. Trivedi, Balaghat.	Do. . .	M. L. .	46	7th February 1935.	Do.
Do. .	(370) Rai Bahadur Seth Gowardhandas of Tumsar.	Do. . .	M. L. .	426	1st April 1935.	30 years.
Do. .	(371) Messrs. B. P. Byramji and Company, Nagpur.	Do. . .	M. L. .	67	17th April 1935.	5 years.
Do. .	(372) Rai Bahadur Seth Gowardhandas of Tumsar	Do. . .	M. L. .	33	29th April 1935.	30 years.
Do.	(373) Do .	Do. . .	M. L. .	71	18th May 1935.	Do.
Do .	(374) Do .	Do . .	M. L .	59	28th April 1935.	Do.
Do. .	(375) Do	Do . .	M. L .	83	1st May 1935.	Do.
Do .	(376) Do .	Do . .	M. L .	69	Do. .	10 years.
Do .	(377) Do	Do . .	M. L .	15	Do. .	Do.
Do. .	(378) Mr Amritlal P Trivedi Balaghat	Do . .	M. L	44	1st October 1935.	30 years
Do .	(379) Do	Do . .	M. L	21	19th June 1935.	5 years.
Do .	(380) Rai Bahadur Seth Gowardhandas of Tumsar	Do . .	M. L	64	18th October 1935.	30 years.
Do .	(381) Do	Do	M. L .	263	29th October 1935.	Do
Do .	(382) Messrs B. P. Byramji and Company, Nagpur.	Do. . .	M. L .	134	24th April 1935.	2½ years.
Do. .	(383) Mr. M. B. Marfatia, Balaghat.	Do. . .	P. L. .	85	25th May 1935.	1 year.
Do. .	(384) Messrs. Oke Brothers of Nagpur.	Do. . .	P. L. .	150	6th July 1935.	Do.
Do. .	(385) Rai Bahadur Seth Gowardhandas of Tumsar.	Do. . .	P. L .	6	Do. .	Do.
Do. .	(386) Do .	Do. . .	P. L .	34	18th July 1935.	Do
Do. .	(387) Mr. Shamji Naranji of Ramtek	Do . .	P. L .	37	8th August 1935.	Do.

P. L. = *Prospecting License.* M. L. = *Mining Lease.*

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Betul . .	(388) Mr. Bansidhar Ramniwas Goenka of Nagpur.	Coal	P. L. .	215	18th January 1935.	1 year.
Do. . .	(389) Do. .	Do.	P. L. .	185	30th November 1935.	Do.
Bhandara .	(390) The Alliance Minerals Company, Limited, Kamptee.	China clay . .	Q. L. .	151	5th April 1935.	10 years.
Bilaspur .	(391) Mr. Asaram, Mahar of Magarpara, Bilaspur.	Clay	Q. L. .	1	25th April 1935.	5 years.
Do. .	(392) Mr. Fakirchand Ghai of Gondpara, Bilaspur.	Limestone . .	Q. L .	4	24th July 1935.	Do.
Do. .	(393) Mr. Tulsiram, son of Domaji, Mahar of Magarpara, Bilaspur.	Clay	Q. L. .	1	15th January 1935.	10 years.
Do. .	(394) Mr. Jairam Valji of Raigarh.	Limestone . .	P. L. .	24	13th July 1935.	1 year.
Do. .	(395) The Agent, Bengal Nagpur Railway Company, Limited.	Clay	Q. L. .	3	16th November 1935.	5 years.
Chanda .	(396) Mr. M. D'Costa, Nagpur.	Coal	P. L. .	347	30th November 1934	1 year.
Do. .	(397) Do .	Do.	P. L. .	121	Do. .	Do.
Do. .	(398) Rai Bahadur Mathura Prasad, Managing Director, Jamai Majri Coal Company, Chhindwara.	Do.	P. L. .	433	28th January 1935.	Do.
Do. .	(399) Messrs. A. H. Vasudeo Rao and Brothers of Nagpur.	Do.	P. L. .	76	6th November 1935.	Do.
Do. .	(400) Sir M. B. Dadabhoy, K.C.I.E., K.C.S.I. of Nagpur.	Do.	Supplementary M. L.	69	10th December 1935.	10 years.
Chhindwara .	(401) The Amalgamated Coal Fields, Ltd., Parasia.	Do.	Supplementary M. L.	3	2nd October 1935.	14 years.
Do. .	(402) Do. .	Do.	Supplementary M. L.	2	13th November 1935.	Do.
Do. .	(403) Seth Bansidhar Ramniwas Goenka of Nagpur.	Do.	M. L. .	267	19th November 1935.	30 years.
Do. .	(404) Do. .	Do.	P. L. .	66	29th January 1935.	1 year.
Do. .	(405) Mr. Syed Jamal of Jamai.	Do.	P. L. .	203	Do. .	Do.
Do. .	(406) Col. A. W. Darby, O.B.E., of Chhindwara.	Do.	P. L. .	238	27th February 1935.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.* Q. L.=*Quarry Lease.*

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Chhindwara .	(407) Mr Syed Jamal of Jamai.	Coal	P. L. .	266	19th March 1935.	1 year.
Do .	(408) The Hirdagarh Collieries, Limited, Ghorawari.	Do.	P. L. .	485	Do .	Do.
Do .	(409) Do. .	Do.	P. L .	479	Do. .	Do.
Do.	(410) Do .	Do	P. L. .	252	Do. .	Do.
Do. .	(411) Mr. Peshorasingh Sial.	Do.	P. L. .	903	21st March 1935	Do.
Do. .	(412) Newton Chikhli Collieries, Limited.	Do.	P. I .	345	2nd March 1935.	Do.
Do	(413) Mr. M D'Costa of Nagpur.	Manganese .	P. L. .	89	15th April 1935	Do.
Do .	(414) Do	Do . . .	P. L. .	34	Do .	Do.
Do	(415) Mr S. Rangiah Naidu of Nagpur.	Do. . . .	P L .	82	26th June 1935.	Do.
Do .	(416) Haji Syed Zahir-ud-din of Chhindwara.	Coal	P L. .	144	3rd July 1935.	Do
Do .	(417) The Central Provinces Contracting and Mining Syndicate of Nagpur	Do	P L. .	524	31st July 1935	Do.
Do	(418) Do	Do.	P I.	146	3rd August 1935.	Do
Do .	(419) Mr Peshorasingh Sial	Do.	P L .	168	Do	Do
Do .	(420) Pandit Shankerlal of Jamai	Do.	P. I.	150	16th August 1935	Do.
Do. .	(421) Messrs. Dhanji Deoji and Sons of Junnordeo	Do	P. L. .	91	Do. .	Do.
Do. .	(422) Mr Peshorasingh Sial.	Do.	P L .	59	9th October 1935	Do.
Do. .	(423) Messrs. N. H. Ojha and Company.	Do.	P L. .	393	16th December 1935	Do.
Do	(424) Do .	Do.	P L. .	384	Do. .	Do.
Do. .	(425) Messrs. Mangalsingh Ishwarsingh Hanspal of Hirdagarh.	Do.	P I. .	262	21st December 1935	Do
Drug .	(426) Mr. Kalika Prasad Choube	Do.	Q L. .	2	27th January 1935	3 years
Hoshangabad	(427) Messrs. Ruda Ladha and Sons, Bagra	Clay . .	P. L	11	12th July 1935.	1 year
Jubbulpore .	(428) Pandit Chakorilal Pathak of Katni.	Bauxite . . .	M. L. .	14	30th May 1935.	10 years.
Do. .	(429) Mr. M. C. Macedo of Delhi.	Limestone . .	Q. L. .	12	11th April 1935.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.* Q. L.=*Quarry Lease.*

CENTRAL PROVINCES—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement	Term.
Jubbulpore .	(430) Messrs. Ghatak Brothers of Katni.	Limestone . .	Q. L .	20	30th April 1935.	10 years.
Do. .	(431) Mr. Sarju Prasad Gour of Katni.	Do. . .	P. L. .	21	27th August 1935.	1 year.
Do .	(432) Mr. Jagmohansingh, Contractor of Jubbulpore.	Clay . . .	Q. L. .	1	16th August 1935.	10 years
Do. .	(433) Mr. G. H. Cook .	Limestone . .	Q. L. .	4	3rd January 1935.	Do.
Do. .	(434) Jukehi Lime Syndicate of Katni.	Do. . .	Q. L.	3	2nd August 1935.	Do.
Do. .	(435) Mr. Ramchandra Gour, Katni.	Do. . .	Q. L .	3	11th October 1935.	Do.
Do. .	(436) Seth Laxmandas of Katni.	Do . .	Q. L. .	8	12th September 1935.	Do.
Do. .	(437) Mr. T. C. Bajan & Co., Katni.	Do . .	Q. L. .	3	10th September 1935.	Do.
Do. .	(438) Mr. G. H. Cook .	Do. . .	Q. L. .	6	27th September 1935.	Do
Do .	(439) Mr. Sukhdeo Prasad, Katni.	Do. . .	Q. L .	3	16th April 1935	Do.
Do. .	(440) Messrs. Burn & Co., Jubbulpore.	Clay . . .	P. L .	36	6th April 1935	1 year.
Do. .	(441) The Central Provinces Cement Company, Ltd., Jubbulpore.	Limestone . .	P. L .	507	8th October 1935.	Do
Do. .	(442) Pandit Chakorilal Pathak of Murwara.	Soapstone . .	P. L. .	73	23rd March 1935	1 year.
Do .	(443) Seth Gangadhar Rameshwardass of Katni	Fireclay, chalk, red and yellow ochre and iron oxide.	P. L.	70	2nd June 1935	Do.
Do. .	(444) Mr. Kanjee Dhanjee of Katni.	Clay . . .	P. L. .	9	20th November 1935	Do
Do. .	(445) Mr. Suchitsingh of Jubbulpore.	Soapstone . .	P. L. .	8	25th February 1935.	Do.
Do. .	(446) Do. .	Do. . .	P. L. .	4	Do. .	Do
Do. .	(447) Mr. G. H. Cook of Katni.	Limestone . .	Q. L .	5	17th September 1935.	10 years.
Nagpur .	(448) Mr. Shamji Naranji of Ramtek.	Manganese-ore .	P. L .	79	10th January 1935.	1 year.
Do. .	(449) Mr. Ganpatrao Laxmanrao of Nagpur.	Do. .	P. L. .	38	30th March 1935.	Do.
Do .	(450) Mr. Maroti Tataji Gadghate of Nagpur.	Clay	P. L. .	9	15th July 1935.	Do.
Do. .	(451) Mr. Shamji Naranji of Ramtek.	Manganese-ore .	P. L. .	102	12th September 1935.	Do.
Do. .	(452) Do. .	Do. . .	P. L. .	14	Do. .	Do.

P. L.=*Prospecting License.* Q. L.=*Quarry Lease.*

CENTRAL PROVINCES—*concld.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nagpur .	(453) Mr. Laxman Damodar Lele of Nagpur.	Manganese .	P. L. .	275	23rd September 1935.	1 year.
Do. .	(454) Mr. Shamji Naranji of Ramtek.	Do. . .	P. L. .	111	22nd November 1935.	Do.
Do. .	(455) Wadgoo Mistry of Kamptee.	Clay . . .	Q. L. .	3	1st March 1935.	5 years.
Do. .	(456) The Central Potteries, Limited, Nagpur.	Pottery clay . .	Q. L.	5	29th May 1935.	10 years.
Do. .	(457) The Central Provinces Contracting and Mining Syndicate.	Manganese-ore .	M. L. .	110	26th April 1935.	5 years.
Do. .	(458) Seth Maghraj Golcha of Nagpur.	Limestone . .	Q. L. .	9	7th October 1935.	Do.
Do. .	(459) The Central Provinces Contracting and Mining Syndicate, Nagpur.	Manganese-ore .	M. L. .	93	1st July 1935.	Do.
Raipur .	(460) Mr. Ishwardas, Raipur.	Clay . . .	P. L. .	13	1st January 1935.	1 year.
Do. .	(461) Mr. Rikhiram, Contractor, Raipur.	Flooring stones .	Q. L. .	6	6th March 1935	5 years.
Do. .	(462) Mr. Wallaramal, Contractor, Raipur	Clay . .	Q. L. .	19	21st December 1934.	Do.
Do. .	(463) Messrs. S. C. Bose and Company, Raipur.	Do . .	Q. L. .	19	31st January 1935.	10 years.
Do. .	(464) Mr. Ganesh Prasad Agarwal, Contractor, Raipur.	Building stones .	Q. L. .	3	2nd April 1935.	Do.
Do. .	(465) Sheikh Kassam, Contractor, Nagpur.	Flooring stones	Q. L. .	11	30th August 1935	Do.
Do. .	(466) Mr. Damji Sheoji, Contractor, Raipur.	Do . .	Q. L. .	20	16th September 1935.	Do.
Yeotmal .	(467) Mr. Sheikh Kassam, Nagpur.	Limestone . .	P. L. .	76	13th August 1935.	1 year
Do. .	(468) Mr. Ganpatrao Laxmanrao, Nagpur.	Do . .	P. L. .	69	17th January 1935.	Do.
Do. .	(469) Mr. T. Z. Thakare, Raipur.	Do. . .	P. L. .	14	13th February 1935.	Do.
Do. .	(470) Mr. F. X. Rebello, Nagpur.	Do. . .	P. L. .	99	6th March 1935.	Do.
Do. .	(471) Mr. Ganpatrao Laxmanrao, Nagpur.	Do. . .	Q. L. .	14	13th February 1935.	10 years.
Do. ..	(472) Mr. M. D'Costa, Nagpur.	Do. . .	Q. L. .	11	15th February 1935.	Do.
Do. .	(473) Do. .	Do. . .	Q. L. .	6	16th July 1935.	Do.
Do. .	(474) Do. .	Do. . .	Q. L. .	3	Do. .	Do.
Do. .	(475) Mr. F. X. Rebello, Nagpur.	Do. . .	Q. L. .	4	9th April 1935.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.* Q. L.=*Quarry Lease.*

MADRAS.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Anantapur	(476) Mr. S. S. Guzdar	Barytes	P. L.	8·09 14·40	1st September 1935.	1 year.
Do.	(477) Do.	Do.	P. L.	27·41	15th March 1935.	Do.
Do	(478) Mr. T Dasaratharami Reddi.	Do.	M. L.	63·22	21st September 1935.	30 years.
Do.	(479) The Indian Mines Development Syndicate, Limited, London	Gold	P. L.	1,293·70 6,268·70	28th November 1935.	1 year.
Do.	(480) Mr. Vishnu Nimkar.	Barytes	P. L.	7 70	28th May 1935.	Do.
Do.	(481) Mr. T. Venkatiah	Steatite	P. L.	7·70	4th June 1935.	Do.
Do.	(482) Mr. Bahadur B P. Sesha Reddi	Do.	P. L.	338·80 253·88	1st September 1935.	Do.
Bellary	(483) Khan Sahib K. Abdul Hye Sahib.	Manganese	P. L.	227·00	17th June 1935.	Do.
Do.	(484) Mr. J Dasaratharami Reddi	Red oxide and red ochre	P. L.	85·00	15th July 1935.	Do.
Cuddapah	(485) Mr. S. S Guzdar	Asbestos	P. L.	45·25	25th March 1935.	Do.
Do.	(486) Mr. K. Balakrishna Nayudu	Aluminium silicate	P. L.	14 00	25th January 1935.	Do.
Do.	(487) Mr. C. Manavalam.	Asbestos	P. L.	120 97	24th June 1935.	Do.
Do	(488) Mr. Narayanadas Giridhardas.	Lead, copper, silver and zinc.	P. L.	236·00	23rd October 1935.	Do.
Do.	(489) Do.	Asbestos	P. L.	514·76	Do.	Do.
Do.	(490) Mr Mayana Hussain Khan.	Do.	P. L.	8 54	30th May 1935.	Do.
Do.	(491) Mr. A. Krishnappa.	Do.	P. L.	20·80	5th June 1935.	Do.
Do.	(492) Mr. S. S. Guzdar	Barytes	M. L.	30·15	1st July 1935.	20 years.
Do.	(493) Do.	Do.	P. L.	8·73	11th November 1934.	1 year.
Do.	(494) Do.	Do.	P. L.	9·20	15th December 1934.	Do.
Do.	(495) Mr. C. C Obayya Chetti.	Do.	P. L.	89·57	26th June 1935.	Do.
Do.	(496) Mr. Narayanadas Giridhardas.	Silver, lead, copper, zinc and antimony.	P. L.	102 10	29th May 1935	Do.
Do.	(497) Mr. C C. Obayya Chetti	Barytes	P. L.	12·22	20th June 1935.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

MADRAS—*contd.*

District.	Grantee	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Cuddapah .	(498) Mr. C. C. Obyya Chetti.	Barytes	P. L. .	38·50	29th August 1935.	1 year.
Do. .	(499) Do. .	Do.	M. L. .	41·00	1st July 1935.	30 years.
Do. .	(500) Mr. Paul Ignatius	Do.	P. L. .	6·00	4th December 1935.	1 year.
Do. .	(501) Mr. S. S. Guzdar	Do.	M. L. .	202·45	1st September 1935.	25 years.
Do. .	(502) Mr. Narayanadas Giridhardas.	Silver, lead, copper, zinc and antimony.	P. L. .	344·87	30th July 1935.	1 year.
Do.	(503) Mr. S. S. Guzdar	Barytes	P. L. .	4·67	16th August 1935.	Do.
Do. .	(504) Do. .	Asbestos . . .	M. L. .	54·30	1st September 1935.	30 years.
Do. .	(505) Mr. C. C. Obayya Chetti.	Barytes	P. L. .	36·40	23rd August 1935.	1 year.
Do. .	(506) Mr. S. S. Guzdar	Do.	P. L. .	30·61	31st July 1935.	Do.
Do. .	(507) Do. .	Do.	P. L. .	80 60	2nd June 1935.	Do.
Do. .	(508) Mr. C. C. Obayya Chetti.	Steatite . . .	P. L .	21 00	27th June 1935.	Do.
Do. .	(509) Mr. S. S. Guzdar	Barytes	P. L. .	41·12	19th July 1935.	Do.
Do. .	(510) Mr. Paul Ignitius.	Do.	P. L. .	2·95	7th August 1935.	Do.
Do. .	(511) Mr. S. S. Guzdar	Do.	P. L. .	84·50	22nd July 1935.	Do.
Guntur .	(512) Mr. P. Veeriah .	Diamond . . .	P. L. .	50·00	31st December 1935.	Do.
Kurnool .	(513) The C. P. Cement Company, Limited, Bombay.	Limestone . . .	M. L. .	3,579·81	17th January 1935.	30 years.
Do. .	(514) Mr. B. P. Sesha Reddi.	Barytes	P. L. .	3·50	14th January 1935.	1 year.
Do. .	(515) Do. .	Do.	P. L. .	56·80	Do. .	Do.
Do. .	(516) Mr. R. F. Nariman.	Do.	P. L. .	32·10	30th January 1935.	Do.
Do. .	(517) Mr. Manji Bachar	Do.	P. L. .	47·20	3rd May 1935.	Do.
Do. .	(518) Mr. S. S. Guzdar	Do.	P. L. .	8·50	29th May 1935.	Do.
Do. .	(519) Mr. Thandu Venkatiah.	Do.	P. L .	26·50	29th July 1935.	Do.
Do. .	(520) Mr. Ashruff Hussain Khan Sahib Mandozic.	Do.	M. L. .	23·70	2nd May 1935.	5 years.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

MADRAS—*contd.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Kurnool .	(521) Mr. Manji Bachar	Barytes . .	P. L. .	3·06	2nd February 1935.	1 year.
Do. .	(522) Mr. B. P. Sesha Reddi.	Steatite . . .	P. L. .	12·30	25th May 1935	Do.
Do. .	(523) Mr. Manji Bachar	Barytes . . .	P. L. .	8·25	2nd February 1935.	Do
Do. .	(524) Do. .	Do. . . .	P. L. .	9 55	Do.	Do
Do .	(525) Mr. Narayanadas Giridhardas.	Do. . .	P. L. .	59·00	6th October 1934.	Do.
Do. .	(526) Mr. B. P. Sesha Reddi.	Steatite . . .	M. L. .	24·64	20th June 1935	10 years.
Do. .	(527) Mr S. S Guzdar	Barytes . . .	P. L .	136·00	7th September 1935.	1 year
Do .	(528) Do. .	Do. . . .	P. L .	46·00	Do .	Do.
Do. .	(529) Mr. Narayanadas Giridhardas.	Silver, lead and zinc	P L .	21·00	7th December 1934.	Do.
Do .	(530) Mr. S S Guzdar	Barytes . . .	P. L. .	19·00	31st August 1935	Do
Do. .	(531) Mr. S. P. Ranga Rao.	Asbestos . .	P. L .	28 60	9th July 1935.	Do
Do. .	(532) Mr. B. P. Sesha Reddi.	Barytes . . .	P. L .	30·00	1st September 1935.	Do.
Do .	(533) Mr. B. Venkataswami Chetti	Do. . . .	P L .	14 50	17th May 1935.	Do
Do. .	(534) Mr. Narayanadas Giridhardas.	Iron-ore and manganese.	P L	77·60	11th July 1935.	Do.
Do .	(535) Mr. B. P. Sesha Reddi.	Barytes . . .	P L .	14·09	25th August 1935.	Do.
Nellore .	(536) Mr. S. V. Subba Reddi	Mica . . .	P L. .	194·51	20th March 1935.	Do.
Do. .	(537) Mr. K. Balakrishna Nayudu.	Do. . . .	P L. .	31·60	1st May 1935.	Do.
Do .	(538) G. Chenchu Subba Reddi.	Do. . . .	P. L.	18 80	14th May 1935.	Do.
Do. .	(539) Mr. K. Venka Subba Reddi	Do. . . .	P. L .	5·14	19th June 1935.	Do.
Do. .	(540) Mr. A. Chengal Rao.	Do. . . .	P. L. .	13·84	14th August 1935.	Do.
Do .	(541) Mr. V. Venkata Subbayya Nayudu.	Do. . . .	P. L. .	6·95	25th September 1935.	Do.
Do. .	(542) Mr. P. V. Subba Rao.	China clay . .	P. L. .	37·14	15th August 1935.	Do.
Do. .	(543) Mr Y. Dasaratharami Reddi.	Mica . . .	P. L. .	54·60	18th October 1935.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

MADRAS—*concld.*

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Nellore	(544) Mr. T. Sesha Reddi.	Mica	P. L.	49·24	4th December 1935.	1 year.
Do.	(545) Mr. P. Laxmi Narasa Reddi.	Kyanite	M. L.	48·00	17th January 1935.	30 years.
Do.	(546) Mr. S. Z. Subba Rami Reddi.	Mica	M. L.	8·80	26th February 1935.	10 years.
Do.	(547) Mr. A. Chengal Rao.	Do.	M. L.	16·85	8th May 1935.	30 years.
Salem	(548) Mr. Narayanadas Giridhardas.	Gold and silver	P. L.	63 36	13th December 1935.	1 year.
Tinnevelly	(549) Mr. Paul Rayar.	Garnet sand	M. L.	2·04	14th November 1935.	3 years.
Trichinopoly	(550) M. Sayyed Ibrahim Sahib.	Phosphatic nodules and gypsum.	M. L.	3,162·57	1st July 1935.	20 years.

NORTH-WEST FRONTIER PROVINCE.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Bannu	(551) Messrs. The Indo-Burma Petroleum Co., Ltd	Natural petroleum (including natural gas).	P. L. (Renewal).	5,913·6	3rd February 1935.	1 year.
Do.	(552) Do.	Do.	P. L. (Renewal).	3,040·0	3rd August 1935.	Do.
Do.	(553) Do.	Do.	P. L.	665·6		Do.
Bannu and Dera Ismail Khan.	(554) Messrs. The Burmah Oil Co., Ltd.	Do.	P. L. (Renewal)	13,248·0	2nd September 1935	Do.
Dera Ismail Khan.	(555) Messrs. The Indo-Burma Petroleum Co., Ltd.	Mineral oil	P. L. (Renewal).	2,995 2	10th September 1935.	Do.
Do.	(556) Messrs. The Attock Oil Co., Ltd.	Do.	P. L. (Renewal)	150·0	26th November 1935.	Do.
Kohat	(557) Messrs. The Indo-Burma Petroleum Co., Ltd.	Natural petroleum	P. L.	3,240 0	15th December 1934.	Do.
Do.	(558) Do.	Do.	P. L.	2,880 0	Do.	Do.

PUNJAB.

District.	Grantee.	Mineral.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Attock	(559) Messrs. The Burmah Oil Co., Ltd.	Natural petroleum	P. L.	1,680·8	20th September 1935.	1 year.
Do.	(560) Do.	Do.	P. L.	854·4	Do.	Do.
Jhelum	(561) Lala Ishar Das Kapur.	Coal	M. L.	182·4	22nd February 1935.	15 years.
Do.	(562) National Coal Company, Chittidand.	Do.	M. L.	1,171·0	20th December 1934.	20 years.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

PUNJAB—*concld.*

District.	Grantee.	Mica.	Nature of grant.	Area in acres.	Date of commencement.	Term.
Jhelum .	(563) Bhai Hazura Mal, Dandot.	Coal . .	M. L. .	72·5	16th December 1935.	15 years.
Do. .	(564) Lala Charanjit Lal, Wahali.	Do. .	P. L. .	1,000·0	15th January 1935.	1 year.
Do. .	(565) Chakwal Brick Company, Chakwal	Do. .	P. L. .	173·0	22nd February 1935.	Do.
Do. .	(566) Do. .	Do. .	P. L. .	53·5	8th March 1935.	Do.
Do. .	(567) Malik Dewa Singh and Sons, Abbottabad.	Do. .	P. L. .	605·0	9th March 1935.	Do.

P. L.=*Prospecting License.* M. L.=*Mining Lease.*

SUMMARY.

Province.	Prospecting Licenses.	Mining Leases.	Quarry Leases.	Total for each Province.
Ajmer-Merwara	15	5	..	20
Assam	6	5	..	11
Bihar and Orissa	8	14	..	22
Bombay	3	2	..	5
Burma	287	20	..	307
Central Provinces	55	24	31	110
Madras	62	13	..	75
North-West Frontier Province	8	..	..	8
Punjab	6	3	..	9
Total of each kind and grand total .	450	86	31	567
Total for 1934 .	376	57	49	482

CLASSIFICATION OF LICENSES AND LEASES.

TABLE 50.—*Prospecting Licenses and Mining Leases granted in Ajmer-Merwara during the year 1935.*

District.	1935.		
	No.	Area in acres.	Mineral.
		PROSPECTING LICENSES.	
Ajmer	1	2·74	Mica and beryl.
Do.	1	0·72	Beryl and felspar.
Do.	4	10·62	Mica.
Do.	1	1·72	Mica, felspar, quartz and beryl-ore.
Do.	1	0·80	Mica, felspar and china clay.
Do.	2	2·64	Felspar.
Do.	2	1·98	Mica, felspar and beryl ore.
Beawar	1	1·66	Do.
Do.	2	8·16	Mica.
TOTAL	15		
		MINING LEASES.	
Ajmer	2	12·60	Mica, felspar and beryl-ore.
Kalera Bogla Estate	1	Whole estate	Mica.
Khawas Estate	1	Do.	Mica and beryl-ore.
Sawar Estate	1	Do.	Do.
TOTAL	5		

TABLE 51.—*Prospecting Licenses and Mining Leases granted in Assam during the year 1935.*

District.	1935. No.	1935. Area in acres.	1935. Mineral.
	PROSPECTING LICENSES.		
Lakhimpur	4	6,523·5	Petroleum.
Sylhet	2	12,467·2	Mineral oil.
TOTAL .	6		
	MINING LEASES.		
Sibsagar	2	1,934·4	Limestone.
Do. . . .	1	1,684·3	Coal.
Do. . . .	1	1,684·3	Fireclay.
Do. . . .	1	1,684·3	China clay.
TOTAL .	5		

TABLE 52.—*Prospecting Licenses and Mining Leases granted in Bihar and Orissa during the year 1935.*

District.	1935. No.	1935. Area in acres.	1935. Mineral.
	PROSPECTING LEASES.		
Singhbhum	7	5,156·90	Chromite.
Do. . . .	1	340·00	Manganese-ore.
TOTAL .	8		
	MINING LEASES.		
Angul	1	594·20	Red ochre.
Hazaribagh . . .	3	247·00	Mica.
Santal Parganas . .	8	19·09	Coal.
Singhbhum . . .	1	478·40	Manganese.
Do. . . .	1	289·28	Chromite.
TOTAL .	14		

TABLE 53.—*Prospecting Licenses and Mining Leases granted in the Bombay Presidency during the year 1935.*

District.	1935.		
	No.	Area in acres.	Mineral.
PROSPECTING LICENSES.			
Ahmedabad . . .	1	9,600	Mineral oil and natural gas.
Kanara . . .	1	203	Manganese-ore.
Thana	1	167	Bauxite.
TOTAL .	3		
MINING LEASES.			
Broach and Panch Mahals	2	44	Manganese-ore.

TABLE 54.—*Prospecting Licenses and Mining Leases granted in Burma during the year 1935.*

District.	1935.		
	No.	Area in acres.	Mineral.
PROSPECTING LICENSES.			
Akyab	1	1,280·0	Natural petroleum.
Amherst . . .	4	4,211·2	All minerals except oil.
Do. . . .	2	2,400·0	Antimony.
Bhamo	2	691·2	Gold and platinum.
Do.	1	51·2	Gold.
Henzada . . .	1	633·6	All minerals other than mineral oil.
Lower Chindwin . .	2	2,342·4	Natural petroleum (including natural gas).

TABLE 54.—*Prospecting Licenses and Mining Leases granted in Burma during the year 1935*—contd.

District.	1935.		
	No.	Area in acres.	Mineral.
	PROSPECTING LICENSES—*contd.*		
Magwe	1	72·9	Natural petroleum (including natural gas).
Meiktila	1	985·6	Antimony.
Mergui	28	8,569·6	Tin and allied minerals.
Do.	44	15,872·0	Tin.
Do.	21	9,964·8	Tin and wolfram.
Do.	4	1,561·6	Tin, wolfram and other allied minerals.
Do.	3	1,563·0	All minerals other than oil.
Do.	1	403·2	Tin and all other minerals.
Do.	7	2,784·0	Wolfram.
Do.	1	748·8	Wolfram and other associated minerals.
Do.	6	1,939·2	Tin and associated minerals.
Do.	1	294·4	Tin and other minerals.
Minbu	1	76·8	Natural petroleum (including natural gas).
Myingyan	3	8,317·4	Do.
Myitkyina	1	1,216·0	All minerals except oil.
Do.	3	6,784·0	Gold and platinum.
Do.	4	2,560·0	Gold.
Northern Shan States	1	160·0	Antimony.
Do.	2	723·8	Iron-ore.
Pakokku	2	938·2	Natural petroleum (including natural gas).

TABLE 54.—*Prospecting Licenses and Mining Leases granted in Burma during the year 1935*—contd.

District.	1935.		
	No.	Area in acres.	Mineral.
			PROSPECTING LICENSES—*contd.*
Salween	2	1,190·4	All minerals except mineral oil, tin and wolfram combined.
Do.	5	3,840·0	Gold.
Do.	1	640·0	All minerals except mineral oil.
Shwebo . . .	1	236·8	Gold or other minerals.
Do. . . .	2	7,987·2	Natural petroleum (including natural gas).
Southern Shan States .	1	1,280·0	Wolfram, lead and antimony.
Do. . . .	7	6,560·0	All minerals except tin.
Tavoy	32	9,192·3	Wolfram.
Do.	40	26,336·0	All minerals except oil.
Do.	1	377·6	Tin and allied minerals.
Do.	1	140·8	Tin and wolfram.
Thaton	1	1,280·0	All minerals except oil and tin.
Do.	1	480·0	All minerals except oil, tin and wolfram.
Do.	1	320·0	All minerals except tin, oil and natural gas.
Thayetmyo . . .	6	8,890·4	Natural petroleum (including natural gas).
Toungoo . . .	2	7,008·0	Gold.
Upper Chindwin . .	1	704·0	Coal.
Do. . . .	4	11,659·0	Natural petroleum (including natural gas).

TABLE 54.—*Prospecting Licenses and Mining Leases granted in Burma during the year 1935*—concld.

District.	1935.		
	No.	Area in acres.	Mineral.
PROSPECTING LICENSES—*concld.*			
Yamethin . . .	19	18,988·8	All minerals except oil.
Do. . . .	1	960·0	Tin and allied minerals.
Do. . . .	1	1,152·0	All minerals except precious stones.
Do. . . .	4	3,296·0	All minerals except oil and tin.
Do. . . .	2	1,120·0	Wolfram.
Do. . . .	3	4,473·6	All minerals except tin.
TOTAL .	287		
MINING LEASES.			
Amherst . .	1	610·0	Tin-ore.
Mergui	2	352·0	Do.
Do.	9	3,897·6	Tin and wolfram.
Tavoy	4	2,400·0	Tin, wolfram and allied minerals.
Do.	1	147·2	Tin and allied minerals.
Do.	1	249·6	All minerals except petroleum and precious stones.
Do.	2	294·4	Tin and wolfram.
TOTAL .	20		

TABLE 55.—*Prospecting Licenses, Mining and Quarry Leases granted in the Central Provinces during the year 1935.*

District.	1935.		
	No.	Area in acres.	Mineral.
		PROSPECTING LICENSES.	
Balaghat . . .	5	262	Manganese-ore.
Betul	2	400	Coal.
Bilaspur . . .	1	24	Limestone.
Chanda . . .	4	977	Coal.
Chhindwara . . .	19	5,567	Do.
Do. . . .	3	205	Manganese-ore.
Hoshangabad . .	1	11	Clay.
Jubbulpore . . .	2	528	Limestone.
Do. . . .	2	45	Clay.
Do. . . .	3	85	Soapstone.
Do. . . .	1	70	Fire clay, chalk, red and yellow ochre and iron oxide.
Nagpur . . .	1	9	Clay.
Do. . . .	6	619	Manganese-ore.
Raipur	1	13	Clay.
Yeotmal . . .	1	258	Limestone.
TOTAL .	55		
		MINING LEASES.	
Balaghat . . .	17	1,837	Manganese-ore.
Chanda . . .	1	69	Coal.
Chhindwara . . .	3	272	Do.
Jubbulpore . . .	1	14	Bauxite.
Nagpur . . .	2	203	Manganese.
TOTAL .	24		

TABLE 55.—*Prospecting Licenses, Mining and Quarry Leases granted in the Central Provinces during the year 1935*—contd.

District.	1935.		
	No.	Area in acres.	Mineral.
	QUARRY LEASES.		
Bhandara . . .	1	151	China clay.
Bilaspur . . .	3	5	Clay.
Do. . . .	1	4	Limestone.
Drug	1	2	Coal.
Jubbulpore . . .	10	67	Limestone.
Do. . . .	1	1	Clay.
Nagpur . . .	1	3	Do.
Do. . . .	1	5	Pottery clay.
Do. . . .	1	9	Limestone.
Raipur	3	37	Flooring stones.
Do.	2	38	Clay.
Do.	1	3	Building stone.
Yeotmal . . .	5	38	Limestone.
TOTAL .	31		

TABLE 56.—*Prospecting Licenses and Mining Leases granted in the Madras Presidency during the year 1935.*

District.	1935.		
	No.	Area in acres.	Mineral.
		PROSPECTING LICENSES.	
Anantapur . . .	3	52·60	Barytes.
Do. . . .	1	7,562·40	Gold.
Do. . . .	2	600·38	Steatite.
Bellary	1	227·00	Manganese-ore.
Do.	1	85·00	Red oxide and red ochre.
Cuddapah . . .	5	710·32	Asbestos.
Do. . . .	1	14·00	Aluminium silicate.
Do. . . .	1	236·00	Lead, copper, silver and zinc.
Do. . . .	13	445·07	Barytes.
Do. . . .	2	446·97	Silver, lead, copper, zinc and antimony.
Do. . . .	1	21·00	Steatite.
Guntur	1	50·00	Diamond.
Kurnool . . .	16	514·05	Barytes.
Do. . . .	1	12·30	Steatite.
Do. . . .	1	21·00	Silver, lead and zinc.
Do. . . .	1	28·69	Asbestos.
Do. . . .	1	77·60	Iron and manganese.
Nellore	8	374·68	Mica.
Do.	1	37·14	China clay.
Salem	1	64·36	Gold and silver.
TOTAL .	62		

TABLE 56.—*Prospecting Licenses and Mining Leases granted in the Madras Presidency during the year 1935*—contd.

District.	1935.		
	No.	Area in acres.	Mineral.
MINING LEASES.			
Anantapur . . .	1	63·22	Barytes.
Cuddapah . . .	3	273·60	Do.
Do. . . .	1	54·30	Asbestos.
Kurnool . . .	1	3,579·81	Limestone.
Do. . . .	1	23·70	Barytes.
Do. . . .	1	24·64	Steatite.
Nellore	1	48·00	Kyanite.
Do.	2	25·65	Mica.
Tinnevelly . . .	1	2·04	Garnet sand.
Trichinopoly . . .	1	3,162·57	Phosphate nodules and gypsum.
TOTAL .	13		

TABLE 57.—*Prospecting Licenses granted in the North-West Frontier Province during the year 1935.*

District.	1935.		
	No.	Area in acres.	Mineral.
Bannu	3	9,619·2	Natural petroleum (including natural gas).
Bannu and Dera Ismail Khan.	1	13,248·0	Do.
Dera Ismail Khan . .	2	3,145·2	Mineral oil.
Kohat	2	6,120·0	Natural petroleum.
TOTAL .	8		

TABLE 58.—*Prospecting Licenses and Mining Leases granted in the Punjab during the year 1935.*

District.	1935.		
	No.	Area in acres.	Mineral.
	PROSPECTING LICENSES.		
Attock	2	2,534·4	Natural petroleum.
Jhelum	4	1,831·5	Coal.
TOTAL .	6		
	MINING LEASES.		
Jhelum	3	1,425·9	Coal.

MARBLE OF THE NORTH-WEST FRONTIER PROVINCE. BY A. L. COULSON, D.Sc. (MELB.), D.I.C., F.G.S., *Superintendent, Geological Survey of India.*

CONTENTS.

. INTRODUCTION.

I visited the Shahidmena (34° 9′ 30″ : 71° 17′ 30″) marble quarries in the Mullagori tribal country of the Khyber Agency on the 16th January, 1936, and the marble deposits of the Kambela Khwar, west of Lowaramena (34° 8′ : 71° 19′ 30″) on the 20th January. I revisited both areas on the 22nd April, 1936.

I visited the marble deposits near Maneri (34° 8′ : 72° 28′) in the Swabi tahsil of the Peshawar district on the 21st January, 1936.

This paper embodies the observations made in the field during those visits, and also includes numerous analyses of specimens of marble that have been kindly made for me in the Laboratory of the Geological Survey of India.

II. MARBLE OF THE MULLAGORI COUNTRY, KHYBER AGENCY.

1. Previous Observers.

The geology of the Khyber hills is known chiefly from certain traverses made by Griesbach and Hayden.

C. L. Griesbach.

In his account of the geology, which forms a separate section in his paper on the geology of the Safed Koh [1], Griesbach considers the limestone and alum shales series that forms the hills in the vicinity of Ali Masjid (34° 2′ : 71° 16′) to be Carboniferous in age. These rocks are underlain by metamorphic strata with graphitic layers, also of Carboniferous age. The oldest rocks, forming his gneissic series and a series of phyllites and schists, are ranked as Older Palæozoic. He states that a fold-fault has brought the older Palæozoic rocks in superposition over the limestone near the Loe Shilman valley, which is a few miles to the north-west of Shahidmena. He notes (p. 91) that

'Hornblendic granite in veins near Sarobi and trap intrusions along the northern (left) side of the valley obscure the section a good deal, but as all the hills north of this line are formed by schists and a gneissic series, the beds of which dip northwest, it seems that they must have been pushed over the relatively younger limestone division, which they now apparently overlie. This structure might possibly be explained as a reversed synclinal, of which the limestone forms the centre; but there is no direct evidence to warrant this assumption; whilst, on the other hand, the great local disturbance and crushing near Umarai, and the appearance of igneous intrusions along a line which is the general strike of the Jalalabad disturbance, speak for a continuance also in this area of the fold-fault (?) on the south flank of the Siah Koh.'

Regarding the Kam Shilman valley, which is to the west of Shahidmena, Griesbach says (*loc. cit.*) that from south to north it forms a normally ascending section, it being the northern half of the anticlinal. He also notes the metamorphic graphitic series overlies the schists conformably.

'They strike more or less along the left side of the valley to near where the road to Shahidmaina branches off to the west [2], where they are overlaid by the dark limestone (*d*, carboniferous ?). The graphitic series forms a regular sequence of semi-metamorphic schists, which are closely connected with the schists below, but which, near the middle of the section, may be described as a great thickness of calcareous phyllites, with occasional micaceous slates intercalated. Lavender-coloured clay shales with beds of bituminous alum shales form several distinct horizons, which contain numerous layers of graphite and graphitic shales.'

[1] *Rec. Geol. Surv. Ind.*, XXV, Pt. 2, pp. 89-93, (1892).
[2] Presumably near Sahib Khan Kalai (34° 10′ : 71° 15′ 30″).

He says that the limestone is in great force near where the Shahidmena road branches off across the metamorphic range (p. 92)

'but immediately north of this point this division is suddenly brought into contact with the mica schist and gneissic series, which are pushed over disturbed beds of the limestone and on the left side of the valley over the graphitic schists which underlie the limestone (*d*).'

He noted that the thin-bedded limestone at the base of the massive limestone in the Kam Shilman valley contains garnets which are also found in the shaly partings between the limestone beds.

Griesbach considered the massive limestone to resemble lithologically very strongly the Carboniferous limestone of the Himalayas and the Hindu Kush, and it is placed by him tentatively as of that age. It is overlain by shales forming the low hills at the entrance to the Khyber Pass before the Ali Masjid limestones, and these shales were considered (p. 92) as

'either upper carboniferous or even younger, and may possibly be found to be of Triassic age.'

H. H. Hayden.

In his account of the geology of the Tirah and the Bazar valley, Sir Henry Hayden [1] refers to Griesbach's description of the limestone of the Ghund Ghar (33° 57′ 30″ : 71° 19′ 30″) at the mouth of the Khyber river and the overlying shale series, with which he found crinoidal and coral limestones interbedded. He concluded that these shales are of Permo-Carboniferous to Upper Carboniferous age, and the fossiliferous limestones are Permian to Permo-Carboniferous, and that probably the whole of the Productus Limestone beds is fully represented. Triassic shales overlie the last-mentioned limestones.

Igneous rocks.

Griesbach mentions [2] intrusive granite altering the limestone and also refers to trap intrusions. Hayden refers [3] to intrusions of a green igneous rock occurring in small patches on, and at the foot of, Ghund Ghar which have altered the dark limestone to a finely crystalline marble of great beauty. He describes the green rock (pp. 115-116) as an enstatite-dolerite composed of plagioclase, augite and enstatite with

'numerous secondary minerals, including chiefly green hornblende, bastite, chlorite and some zoisite. Ilmenite is very common, in every stage of alteration.'

[1] *Mem. Geol. Surv. Ind.*, XXVIII, Pt. 1, pp. 108-114, (1898).
[2] *Op. cit.*, p. 91.
[3] *Op. cit.*, p. 109.

The parent plutonic rock is probably an enstatite-gabbro, not found *in situ*.

C. S. Fox.

In his paper entitled 'Geological considerations which appear to affect the safety of the Khyber Railway', published by the North-Western Railway Press in Lahore in 1926, Dr. C. S. Fox has referred (p 2) to the previous visits of Griesbach and Hayden and has given a minute description of tunnel sections along the Khyber railway. He refers (*loc. cit.*) to boulders of quartzite, sandy ferruginous limestone and grey limestone containing crinoids and brachiopods found just north of Jamrud station. He considers it possible that these have come from the Khyber and represent strata seen *in situ* by Sir Henry Hayden near Walai and China in the north side of the Bazar valley. The fossils found by Dr. Fox were thought by Mr. G. H. Tipper [1] to afford some indication of a Devonian age. However, Sir Henry collected Upper Carboniferous to Permian fossils from these limestones and so the locality of the Devonian blocks is uncertain.

L. L. Fermor.

In January, 1935, Sir Lewis Fermor visited the marble quarries at Shahidmena and also at Maneri in the Peshawar district, and I have examined and registered his hand specimens and thin sections Sir Lewis noted the aegirite which occurred in his section of the biotite-aegirite-arfvedsonite-gneiss to which I refer on page 333. He did not collect his observations on the marble deposits in the form of a report.

A. L. Coulson.

In a separate paper entitled 'A Soda-Granite Suite in the North-West Frontier Province', which I read recently before the National Institute of Sciences of India, I have described the above rock and certain allied porphyries occurring in the Peshawar district which have been analysed.

2. Geological Notes.

(i) *Structure.*

With this somewhat lengthy, but very necessary account of the work of previous observers, we may now turn to a discussion of the Shahidmena-Lowaramena marble area.

[1] *Rec. Geol. Surv. Ind.*, LXIII, Pt. 1, p. 22, (1930).

There is little doubt that the Shahidmena limestone, which has been altered to marble by intrusions of epidiorite dykes, is the same limestone as that of Ali Masjid and Ghund Ghar, considered by Griesbach and Hayden to be Carboniferous in age. It seems to form the upper part of the Agham Dabbar hill (4,033 feet) and to stretch towards Jawaramena and Lowaramena, following the road alignment but about a quarter of, to half, a mile west of it.

Carboniferous limestone altered to marble.

The limestone appears definitely to underlie a series of schists near Lowaramena with no apparent dislocation. If Griesbach's interpretation of the relative ages of the schistose series and the limestone be correct, then the limestone is the younger and the schists may be either his metamorphic strata with graphitic layers, or his phyllites and schists, the anomalous position being due to overfolding or reversed faulting following a break along the limb of a recumbent syncline.

Inverted succession.

The limestone is underlain by a metamorphic series with graphitic layers in the Kambela Khwar, three-quarters of a mile northeast of Kambela, which seems to differ from the schists at Lowaramena. Therefore if the anomalous position be due to overfolding, then we should expect similar graphitic schists to overlie the limestone and to occur between it and the schistose series. This is apparently not the case, and we must conclude that if Griesbach be correct, then there is a reversed fault between the limestone and the schistose series which appears to overlie it without dislocation.

A schistose series extends from west of Lowaramena eastwards towards the edge of the hilly country by Paindai Lalma. It consists of phyllites, shales, and mica-, chlorite- and hornblende-schists, with occasional limestones, all abundantly showing reef quartz. The metamorphism of this series varies greatly. There is a carbonaceous shale of no economic importance cropping out by the side of the road at mile 34/2; this may be part of the schistose series, or alternatively of the metamorphic graphitic series that underlies the limestone. The large width of outcrop of the schists may be due to repetition of both of Griesbach's series. Greenstone dykes intrude the schists. The general foliation is north and south, but the strike is interrupted to the south by the rocks forming the range with the high peaks of Shahid Sar (4,720 feet), Khono Sar (4,129 feet) and Rotaz Sar

Schistose series.

(2,238 feet), which were not visited but which stretch S. S. E. towards Jamrud Fort. To the north, the ridge culminating in Patigate Sar (2,669 feet) has the same strike, cutting across the foliation of the schists.

Patigate Sar is composed of a most interesting biotite-aegirite-arfvedsonite-gneiss (soda-granite) which I have described elsewhere.

Soda-granite.

This granite may doubtfully be the same as the granitic intrusions mentioned by Griesbach. It certainly is not his 'grey thick-bedded gneiss' of his 'gneissic series', which is overlain by phyllites and schists. It appears younger than the epidiorite dykes and sills which have been responsible for the conversion of the limestone into marble; these generally follow the foliation. The granite is possibly Mesozoic in age. As yet unexposed masses of it may have assisted in the metamorphism of the limestone to marble near Shahidmena.

(ii) *Shahidmena marble.*

The geological structure of the Agham Dabbar hill is somewhat indefinite. It is possible that a fault runs N. N. E. along the line

Structure indefinite.

of the Tauda Oba Khwar. The rocks at the foot of Shahidmena village dip at high angles and are very contorted. Arenaceous, calcareous and schistose rocks, intruded by epidiorite sills and showing abundant reef quartz, form the ridge running north-east between the Tauda Oba Khwar and the Kara Shilman Khwar. Griesbach's descriptive notes are not clear, but it appears that these form part of his 'phyllites and schists series' (Older Palaeozoic).

A tremolitic marble was noted in contact with an epidiorite dyke three-quarters of a mile north-east of Shahidmena. Most of the original ferromagnesian minerals in the epidiorite have been converted to hornblende, but there is still some original enstatite and diopside-augite. Other minerals are epidote, zoisite, chlorite, quartz, felspar, abundant sphene and iron-ore. Perhaps these epidiorites are of Panjal trap age.

In the bend of the Kabul river around Shapale Jar, the rocks dip to the east and E. N. E.; these are apparently schistose rocks,

? Recumbent syncline.

but it was not possible to visit them. We may conclude, however, that the limestones and marble of Shahidmena, on the southern side of the river, to be

part of a recumbent syncline, the beds of which dip generally eastwards at varying angles under older schistose rocks which have been pushed above them.

Upper and lower quarries.

At Shahidmena, two main quarries have been commenced on the spur on which the Mullagori road begins to zig-zag down to the level of the Tauda Oba Khwar. These may for convenience be termed the upper and lower quarries. The dips in the vicinity of these quarries are very uncertain, and the marble is mixed up with shales and intrusive epidiorite dykes. However the general dip is easterly, though it seems to change to north on the northern end of the spur by the lower quarry.

Development work.

In the interval between my visits, considerable development work was done. Most of the marble recently opened up in the upper quarry seems to be of the same type as certain banded varieties in the Kambela Khwar and accordingly is not a pure, white, saccharoidal marble. On the other hand, the marble exposed in the lower quarry is a considerable quantity of pure, white, saccharoidal, statuary marble of fair depth- greater than 30 feet - and unproved thickness. As the metamorphic agents which have changed the grey Carboniferous limestone into white marble are possibly only greenstone dykes and sills, one cannot expect a very great thickness of marble on either side of the basic intrusions. At Shahidmena, however, in contradistinction to Maneri, the greenstone dykes so far have not been exposed to any great extent by quarrying. The exposed face of the marble dips eastwards into the hillside and so it will be difficult to work as the overburden will increase as one excavates further. It has been suggested that one should blast away the hillside and then cut up the resultant blocks *in situ*. A short chute down to the old railway embankment along the Kabul river, which could be used for bullock-carts at no great expense, has also been advocated.

Analyses.

The Shahidmena marble is of extremely good quality as will be seen from the analyses listed in Table 1. These were performed in the Laboratory of the Geological Survey of India and are of typical samples of the pure, white, statuary marble from the upper and lower quarries. The analyses of two of the Makrana (Jodhpur) marbles and of the Carrara (Italy) marble, given for purposes of comparison, have been

recalculated from the analyses given by Dr. Heron [1] in his description of the Makrana marble; that of specimen 42/562 is quoted from the same paper.

TABLE 1.—*Analyses of Shahidmena, Makrana and Carrara marble.*

Rock number	49/502	49/462	..		42/562	
Locality	Upper quarry, Shahidmena	Lower quarry, Shahidmena	Makrana	Makrana	Makrana	Carrara.
	Per cent	Per cent.	Per cent.	Per cent	Per cent	Per cent
SiO_2	0·04	0·02	0·98[2]	0·89[2]	0·46	*trace*
$Al_2O_3 + Fe_2O_3$	0·10	0·10	0·16	0·28	0·04	0·11
CaO	55·44	54·60	55·16	54·73	56·08	55·64
MgO	0·70	1·61	0·39	0·58	0·90	0·41
Loss on ignition	43·74	43·86	43·77	43·65	43·28	44·17
P_2O_5	.	.	0·03	0·04	.	*trace*
TOTALS	100·02	100·19	100·49	101·17	100·76	100·33
Specific gravity	2·72	2·72	.		2·73	.

It will be seen that that Shahidmena stone is equal in purity to the Makrana marble and only very slightly less pure than the Carrara marble. The percentage of silica in the Shahidmena marble is less than 0·05 per cent. which is extraordinarily good. However, for ordinary building purposes, insoluble matter will not affect the value of a limestone or marble unless it be concentrated in irregular masses in sufficient quantity to cause the rock to weather differentially or to affect the ease with which it can be dressed. For statuary purposes, freedom from aggregates of quartz grains is more essential.

Both Shahidmena specimens are only very slightly magnesian, the lower quarry sample containing less than 2 per cent.

(iii) *Kambela Khwar marble.*

The metamorphosed Carboniferous limestone forms high cliffs on either side of the Kambela Khwar south-west of Lowaramena.

[1] A.M. Heron, *Trans. Min. Geol. Inst. Ind.*, XXIX, Pt. 4, p. 326, (1935).

[2] Insoluble residue.

Little infiltration of metamorphosing basic magma.

A large quantity of the limestone near the level of the stream bed has been metamorphosed by intrusive epidiorite dykes and sills to a fairly well jointed marble, dipping gently eastwards at about 30°. A specimen showing the junction between an epidiorite dyke and marble, one mile south-west of Lowaramena, shows surprisingly little infiltration of the magma, though the original limestone has been all recrystallised to marble.

Analyses.

The quality and nature of the marble occurring in the Kambela Khwar vary greatly. Certain of the hand specimens are very deceptive, containing a large amount of silica not always recognizable in the field. On this account, I paid a second visit to the Kambela Khwar in order to collect as many varieties as possible for analysis. The specimens in question were analysed with the results given in Table 2.

As has been stated, the recognition in the field of the pure types, except the white, saccharoidal marble, is not always easy. The higher specific gravity of the purer kinds, however, is a general indication, though the banded grey and white marble from the Lowaramena path seems aberrant.

More pure white marble at Shahidmena than in the Kambela Khwar.

It would appear that there is more pure, white marble at Shahidmena than in the Kambela Khwar. In the latter place, the thickness of pure white marble seems to be of the order of six to eight feet on either side of the intrusive and metamorphosing epidiorite dykes and sills, as noted in the exposure south-west of Lowaramena. Again the deposit of pure white marble 1¼ miles W. S. W. of that village does not appear to have any great thickness, and is capped by whitish, impure, banded marble. However, the metamorphism is not limited to the formation of pure white marble; and beyond the limits stated, less recrystallised marbles occur. As will be seen later, I do not recommend the working of the pure white marble alone.

Development.

By Abney level observations, it would appear that the banded marble capping the pure white marble 1¼ miles W. S. W. of Lowaramena is at about the same elevation as Lowaramena and, accordingly, it might be possible to use an aerial ropeway were energies concentrated here. On the other hand, the deposit of pure white marble just south-west of Lowaramena is at a lower level than the village; but it could easily be tapped

TABLE 2.—*Analyses of marble from the Kambela Khwar.*

Rock number.	49/469	49/481	49/482	49/483	49/484	49/485	49/486	49/487	49/488	49/498
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
SiO_2 . .	2·30	28·83	49·04	55·57	0·54	0·06	1·19	0·28	0·01	25·04
$Fe_2O_3+Al_2O_3$.	0·86	1·85	4·70	1·53	0·84	0·18	0·28	0·20	0·46	0·45
CaO . .	53·48	37·59	23·60	21·29	53·98	54·40	53·46	53·96	54·59	39·48
MgO . .	0·78	0·54	0·53	2·44	1·09	0·88	0·09	1·79	0·75	2·11
Loss on ignition	42·42	29·82	21·61	19·38	43·08	43·69	43·15	43·75	43·74	33·18
TOTALS .	99·84	98·65	99·48	100·21	99·53	99·21	98·17	99·98	99·55	100·26
Specific gravity	2 73	2·70	2·69	2·69	2·76	2·70	2·71	2·89	2·72	2·71

49/469.—White and yellowish marble, below ravine, Kambela Khwar. (Analyst—Mahadeo Ram.)
49/481.—Flesh-coloured, siliceous marble, below ravine, Kambela Khwar. (Analyst—Mahadeo Ram.)
49/482.—Very siliceous, white, calcareous rock with few grey bandings, below ravine, Kambela Khwar. (Analyst—R. B. Ghosh.)
49/483.—Very siliceous, calcareous rock with grey bandings, 400 yards above ravine, Kambela Khwar. (Analyst—R. B. Ghosh.)
49/484.—White marble with faint reddish tinge, 600 yards above ravine, Kambela Khwar. (Analyst—R. B. Ghosh.)
49/485.—Pure, white, saccharoidal marble, Kambela Khwar, 1¼ miles W.S.W. of Lowaramena. (Analyst—Mahadeo Ram.)
49/486.—Practically white marble, below ravine, Kambela Khwar (near 49/481). (Analyst—Mahadeo Ram.)
49/487.—Pure, white. saccharoidal marble. by side of dyke near path to Lowaramena, on right-hand side of Kambela Khwar. (Analyst—Mahadeo Ram.)
49/488.—Banded grey and white marble on path to Lowaramena from the Kambela Khwar. (Analyst—R. B. Ghosh.)
49/498.—White, siliceous marble, above ravine, Kambela Khwar. (Analyst—Mahadeo Ram.)

by a short feeder road up the Kambela Khwar to join with the Mullagori road. It has abundant handsome banded marble near it.

Certain of the banded varieties of the Kambela Khwar form very handsome stones suitable for general building purposes, facing work, tiles, etc., and illimitable quantities seem available. With little or no difficulty, suitable spots for the extraction of different types of marble could be chosen. There is a very large number of big masses of marble in the bed of the Khwar which will probably suffice ordinary demands for some time.

(iv) *General descriptive details.*

The following descriptive notes concern chiefly the Shahidmena marble, but will be equally applicable to some of the Kambela Khwar marble.

The marble is a pure, white, saccharoidal stone, translucent in thin masses and equal in appearance to the Makrana marble of Jodhpur and Carrara marble. It has been worked successfully into translucent ornamental vases and vessels, plates, etc., of great beauty. It has been used as an ornamental building stone (polished and unpolished) on a small scale in Peshawar for flooring, fire-places, etc. It has been used also for flooring with black slate from the quarries just over a mile south-west of Jahangira Road railway station (33° 57′ 30″: 72° 12′).[1]

Use of the marble.

The Shahidmena white marble, sawn but not polished, costs about As. 11 per square foot in Peshawar; this may be compared with Makrana marble, also sawn and unpolished, which costs Re. 1 to Re. 1-1 per square foot in Peshawar.

Working costs.

After being roughly dressed at the quarries, the Shahidmena marble is carted by motor-lorry along the rough Mullagori road for about 26 miles to Peshawar, where it is sawn in a factory recently installed by the Director of Agriculture and Allied Departments near the goods railway siding. The blades used are of cold carbon steel, employing a cutting sand from a river-bed between Adina and Kalu Khan (34° 13′: 72° 18′), near mile 15 on the Mardan-Swabi

Factory treatment in Peshawar.

[1] The cost of this slate delivered in Peshawar was about As. 5 per square foot, or Rs. 30 per 100 square feet. Splits one to three inches were obtained. The slate replaced Chitorgarh slate which cost in Peshawar about As. 9 per square foot.

road. This sand contains a lot of felspar, which reduces its cutting power.

Thus the saws cut through about seven-eighths of an inch of marble per hour when Kalu Khan sand is used, as opposed to 1¼ inches per hour cut by quartz sand from near Makrana. However, the local sand does not give so many scratches on the cut surface as does the Makrana sand, and so it does not require the same amount of polishing to remove the grooves. Again Kalu Khan sand costs Rs. 28 per 100 cubic feet delivered in Peshawar, whereas Makrana sand costs Rs. 100 per 100 cubic feet in Peshawar. Finally, though the makers state the saw-blades will last six weeks, they were actually lasting 2½ to 3 months with the local sand. It would appear, therefore, that additional advantages from the use of the local felspathic sand more than compensate for its disadvantages[1].

Old railway alignment.

The question of shipping the marble in barges, or of floating it on rafts, down the Kabul river and its canals to Peshawar has, I understand, been discussed and abandoned partly on account of the possible objection of the tribes through whose territory the marble would pass. I have mentioned previously the old railway embankment along the southern bank of the Kabul river that was built for the strategic railway that was never completed. The dressing factory has already been constructed at Peshawar, but it would be logical to transfer this to the railhead should it ever be necessary to construct the railway. Certainly this railway would better enable the marble to compete in markets other than local, as it would avoid much unnecessary handling and cartage.

III. MARBLE OF THE PESHAWAR DISTRICT.

1. Introductory.

The production of limestone from the Peshawar district has been recorded almost continuously since 1912. In the returns of mineral production from the North-West Frontier Province, much of the so-called limestone and *kankar* is thought to be building stone other than these. It is believed that the chief place from which limestone or marble has been extracted is Maneri (34° 8′ : 72° 28′).

[1] Sand from the Mullagori country was tried unsatisfactorily in the factory. This costs Rs. 20 per 100 cubic feet. It is necessary, whatever sand is used, whether Kalu Khan or Mullagori, that it should first be screened.

2. Nowshera Tahsil.

The ridge with hill 1,186 feet, which strikes east and west across the road between Nowshera and Risalpur, contains a pink marble which will be an useful stone for certain coloured ornamental work. A section (24350) of a specimen (49/595) of this from half a mile south-west of Kandar (34° 2′ : 72° 0′) shows that the pink colour is apparently due to iron-ore. The rock seems to have been a ferruginous limestone which has suffered metamorphism, one of the effects of which is that bands of clear calcite traverse the rock.

Pink marble.

This is probably the same marble as that said to form the hill Pir Sabak Dheri (1,276 feet), north of the Kabul river and about three miles E. N. E. of Nowshera Cantonment, which I was unable to visit. It does not appear to be a well-jointed stone and thus will probably be difficult to quarry into large blocks. It is probably the stone that is burnt for lime in the kilns near Nowshera.

3. Swabi Tahsil.

The chief marble of the Peshawar district is found at Maneri in the Swabi tahsil, where variously coloured stones have been obtained. The marble has been formed by the alteration of a dark-coloured limestone by intrusive epidiorite dykes, which are very numerous. The original limestone seems undoubtedly the same Carboniferous limestone as that of the Khyber Agency, described previously, and the intrusive dykes and sills also similar and possibly of Panjal trap age. In no section was any original ferromagnesian mineral seen, all being altered to hornblende.

Marble of Carboniferous age.

The old quarries are on the southern flanks of hill 2,006 feet, just north and north-east of Maneri Bala. The strata are highly folded and buckled, but a good anticline may be observed under the south-western spur of the hill. Dips generally are in all directions and the amount of marble that may be quarried is very seriously limited by the amount of intrusive epidiorite dykes and sills.

Old quarries.

The colour of the marble varies according to the amount of metamorphism. White marble (49/475) is quarried high up the hill and the blocks rolled down for rough-dressing at its foot. The chief other varieties are grey,

Analyses.

green and yellow. Analyses by Mahadeo Ram of three types found at Maneri are given in Table 3.

TABLE 3.—*Analyses of marble from Maneri, Peshawar district.*

Rock number	49/473	49/474	49/475
Slide number	24354	..	..
Description.	Green serpentinous marble.	Grey marble.	White marble.
	Per cent.	Per cent.	Per cent.
SiO_2	7·34	0·02	0·04
$Al_2O_3+Fe_2O_3$	0·76	0·05	0·05
CaO	45·65	55·86	55·86
MgO	7·34	0·29	0·33
Loss on ignition	38·13	43·47	42·58
TOTALS	99·22	99·69	98·86
Specific gravity	2·71	2·74	2·71

The green serpentinous marble contains some 7½ per cent. of silica and the same amount of magnesia. It is practically ophicalcite. The grey and white marbles are of the same order of purity as the white marble at Shahidmena, being practically pure calcite.

Occurrence of green serpentinous marble.

The green serpentinous marble of Maneri occurs for a width of a few feet only on either side of a relatively large, spheroidally weathering epidiorite dyke, striking approximately N.N.E.-S.S.W. across the saddle between hill 2,006 feet and the spur running S.S.W. towards Maneri. Yellow serpentinous marble of considerable beauty is known to occur a short distance away from the green variety, but I did not visit this.[1] I suspect that its mode of

[1] According to Mr. Beer, a long thin band of yellow mottled serpentine occurs at Darsang, which is probably the hill Dang Sar, 2,045 feet, 2½ miles north-east of Maneri Bala and forming the frontier with Swat territory. 'This is very difficult to quarry as the hammer and chisel only splinter it up, but I think it may be cut into panels with a wire saw, and by its use tiles and panels and table tops of any thickness may be cut, both in yellow and bluish green rock. After polishing, this would look very handsome, the green especially, if alternated with white in a flooring would have a cool and clean effect.'

occurrence will be found to be similar and that its amount also will be strictly limited. These green and variously coloured varieties form very handsome stones which take a good polish. They would be suitable for facing work or for coloured aggregates in mosaic work.

The white marble is of the same nature as the Shahidmena marble, being a pure, white, saccharoidal stone of handsome appearance.

Earlier geological reports.

Through the courtesy of the Director, Department of Agriculture and Allied Departments, I have been enabled to see the geological report on the Swabi marble by E. J. Beer, Esq., for the Frontier Marble Syndicate, made as a result of his inspection in 1923. I understand that owing to certain difficulties with the local inhabitants and restrictions imposed by the Local Government, this syndicate, which was formed for the extraction of marble from certain quarries, did not pursue the matter further.

Four representative specimens of marble from the Swabi tahsil (47/337-340) were sent to the Director of the Geological Survey of India by the Director of Agriculture in July, 1934. These were a white marble of medium grain and uniform texture, translucent in thin section; a grey marble, coarse in grain and not so uniform in texture; a green marble, fine-grained and containing small amounts of tremolite; and a yellow-green marble, fine-grained and mottled white, light grey and yellow-green.[1]

These specimens are typical of the varieties I observed.

Other reported occurrences of grey limestone and white marble.

Grey limestone is said to occur at Kala, Darra and Shah Mansur, south of Swabi, in the hill masses of Panjpir Ghar and Shah Mansur Ghar, and poor quality limestone at Ambar (34° 3′ : 72° 25′). This will be the same grey limestone, unaltered to marble by epidiorite dykes and sills. A white marble is said to occur north of the hill of porphyry called Gohati at mile 24 on the Mardan-Swabi road. This will possibly be the hill Ghundai Tarako (34° 13′ : 72° 25′) on the Swat border which I hope to visit in the forthcoming field season.[2]

[1] See also M. S. Krishnan, *Rec. Geol. Surv. Ind.*, LXX, p. 412, (1936).

[2] Mr. Beer mentions that Sagai Hill is almost made up of white marble, mostly badly cracked and flawed, but with some beautiful white quality among the rest, ' good enough for any small or medium work, and as white as that at Makrana, which place can hardly compete in quantity with the Swabi Hills '. Sagai Hill is presumably the hill at Maneri described on page 19.

The approximate cost of a rough-dressed, squared stone is about Re. 1-8 per cubic foot at Swabi. Transport for 72 miles by road to Peshawar *viâ* Mardan costs about Re. 1 per cubic foot. The largest size of blocks that can be won by ordinary tools at Maneri is said to be about nine by six by six inches. It has also been asserted that the maximum size of blocks available is about 24 by 12 by eight inches, though usually the largest blocks quarried are about 12 by 12 by eight inches. At the time of my visit, there were a few blocks of white marble 24 by 18 by nine inches lying at the foot of the hill; but I think that there will be difficulty in supplying this large size owing to the contorted folding to which the strata have been subjected and the abundant intrusion of epidiorites. The size of blocks here at Maneri is certainly smaller than at Shahidmena.

Transport charges and size of blocks at Maneri.

The nearest railway station from which the Maneri marble can be despatched is Jahangira Road, some 22 miles away to the south-west and across the Kabul river by the bridge of boats at Jahangira. The road through the village of Maneri Bala is impassable to bullock-carts, and donkeys would have to be used for transporting any marble quarried to the road. It is very necessary to reconstruct the disused road from mile 27/3 on the Mardan-Swabi road to cross the Badri Khwar and join with the quarries—a total distance of about three-quarters of a mile.

IV. DOLOMITIC MARBLE OF THE KURRAM AGENCY.

I received recently from the Director of Agriculture in the North-West Frontier Province a boulder of white, crystalline dolomite (49/456, 24362) found in the Zeran Tangi a few miles east of Parachinar (33° 54′ 30″: 70° 6′) in the Kurram Agency. The Zeran Tangi here does not have a very large watershed and there seems little doubt that the dolomite forms part of the ?Devonian limestone series noted by Dr. Cotter in 1926.[1]

Locality near Parachinar.

[1] *Rec. Geol. Surv. Ind.*, LX, pp. 102-103, (1928).

Analysis.

The following analysis by R. B. Ghosh indicates the nature of the rock, which would form a very handsome building stone:—

	Per cent.
SiO_2	2·04
Fe_2O_3 etc.	0·84
CaO	30·77
MgO	20·42
Loss on ignition	43·86
TOTAL .	97·93
Specific gravity	2·90

The thin section of the dolomite shows small amounts of tremolite to be present.

V. CONCLUSIONS.

Quantities available.

There is little doubt that there is more first class, pure, white, saccharoidal, statuary marble, at least equal in quality and appearance to Makrana marble, available at Shahidmena than either at Maneri or in the Kambela Khwar. But I doubt if any one of these deposits alone would be able to keep up the regular supply of a large quantity, such as say 600 tons (=600×15=7,800 cubic feet of marble of specific gravity 2·75) per month of first class, white, statuary marble. Allowing only 25 per cent. wastage, this quantity would entail the monthly removal of marble of dimensions about 40 by 26 by 10 feet.

All three deposits should be developed simultaneously.

I consider that for the best development of the marble industry in the North-West Frontier Province, it is advisable to develop simultaneously the Shahidmena, Kambela Khwar and Maneri deposits. Also every possible care should be taken to extract the less valuable, banded, relatively impure marbles at the same time as the pure white marble, which at all times will command a market. By doing so, large quantities of good quality, banded marble, suitable for tiles, facing and general building purposes, which otherwise would be wasted, will be sold in addition to the statuary marble.

There is no reason why the North-West Frontier Province should import limestone or marble from other provinces of India.

MISCELLANEOUS NOTE.

Quarterly Statistics of Production of Coal, Gold and Petroleum in India : April to June, 1936.

Coal.

—	April.	May.	June.	Quarterly total for each Province.
	Tons	Tons	Tons	Tons
Assam	19,074	16,819	17,045	52,938
Baluchistan . .	371	229	318	918
Bengal.	605,797	585,391	549,123	1,740,311
Bihar	1,067,982	1,071,849	947,811	3,087,642
Orissa	3,374	2,397	2,591	8,362
Central Provinces . . .	133,967	130,888	127,132	391,987
Punjab	15,716	16,602	13,423	45,741
TOTAL .	1,846,281	1,824,175	1,657,443	5,327,899

Gold.

—	April.	May.	June.	Quarterly total for each Company.
	Ozs.	Ozs.	Ozs.	Ozs.
The Mysore Gold Mining Co., Ltd.	7,911	8,168	7,883	23,962
The Champion Reef Gold Mines of India, Ltd.	5,694	5,866	5,696	17,256
The Ooregum Gold Mining Company of India, Ltd.	4,151	4,204	4,181	12,536
The Nundydroog Mines, Ltd. .	9,203	9,722	9,615	28,540
TOTAL .	26,959	27,960	27,375	82,294

Petroleum.

——	Crude Petroleum.	Total gasolene from natural gas.*
	Gallons	Gallons
Assam	15,401,096	*Nil.*
Burma	67,416,773	2,260,233
Panjab	1,080,080	107,416
TOTAL	83,897,949	2,367,649

* These figures represent the total amounts of gasolene derived from natural gas at the well-head. Of these amounts, a portion is sold locally as 'petrol' and the remainder is mixed with the crude petroleum and sent to the refineries. The figures given in the two columns, therefore, together represent the total 'raw products' obtained. These remarks apply to the similar totals quoted in previous *Records*.

A. M. HERON.

MGIPC—M—VIII-4-8—28-9-36—820.

ERRATA.

Page 93, under Bajpai, M. P., *for* '(c)' *read* (*f*), *for* '***Op. cit.***,' *read* '***Proc. Twenty-second Ind. Sci. Congr.*** (*As. Soc. Bengal*)', and *for* items '(*d*), (*e*), (*f*)' *read* '(c), (*d*), (*e*)'.

Page 94, under Chakravarti, *insert* '(*e*) Is Lametasaurus indicus an Armoured Dinosaur?' *Amer. Journ. Sci.*, Vol. XXX, 138-141, (August, 1935.)

Page 344, line 16 from bottom, *for* '7,800' *read* '9,000'.

Page 344, line 13 from bottom, *for* '26' *read* '28'.

RECORDS

OF

THE GEOLOGICAL SURVEY OF INDIA.

Part 4] 1937 [October

Richard Dixon Oldham : Born 30th July, 1858 : Died 15th July, 1936.

It is with great regret that I have to record the death, at Llandrindod Wells on the 15th July 1936, of Richard Dixon Oldham, F.R.S., the doyen of the Geological Survey of India. He was born on the 30th July 1858, the third son of Dr. Thomas Oldham, F.R.S., the founder and first Director of that Department, and was a relative of other former members, so that family traditions, combined with his own inclinations and ability, inspired him to give his best to the service to which he devoted the first half of his working life. He was educated at Rugby and the Royal School of Mines and joined the Geological Survey of India in December 1879 as a third-grade Assistant, a year after the death of his father, who had died two years after retirement. Passing through the various ranks, he became a Superintendent on the 1st October 1891, officiated as Director from the 8th May 1896 to the 23rd November 1897, and retired from the service on the 2nd May 1904.

After his first season in the Godavari valley Oldham commenced that series of researches in the geology of the outer Himalaya which formed perhaps the main occupation, other than seismology, of a quarter of a century of varied fieldwork. In 1881-82 he accompanied the Manipur-Burma Boundary Commission to Manipur State and the Naga Hills, and in 1884-85 was with the Survey of India party in the Andaman Islands. In 1885-86 he toured the geologically unexplored desert region of north-western Rajputana, chiefly with a view to finding coal. In 1886-87 he worked in the Salt Range, in 1889-91 in Baluchistan and in 1901-02 in the Sulaiman Hills. From

1893 to 1899, interrupted by his appointment as Officiating Director and his investigation of the Assam earthquake of 1897, he was in charge of a party consisting of Messrs. P. N. Datta and E. W. Vredenburg in the Son Valley. His last field-work was in the Lower Chindwin and Pakokku districts, Upper Burma. After retirement he visited Burma again for a cold weather in a consultant capacity in oil to Messrs. Steel Bros. and Coy., Ltd.

This wide experience admirably equipped him for his selection, by the late Dr. W. King, to write the second edition of the official "Manual of the Geology of India" (1893), the groundwork of which he had earlier compiled in his "Bibliography of Indian Geology" (1888). The second edition of the Manual was in all important respects a new work, though based on the first edition by H. B. Medlicott and W. T. Blanford, and several of the new chapters were of universal geological interest beyond purely Indian problems. Before this he had edited his father's unpublished papers on the "Cachar Earthquake of 1869" (1882), on the "Thermal Springs of India" (1882) and the "Catalogue of Indian Earthquakes" (1883); these probably first attracted his attention to seismology, which culminated in his exhaustive memoir on the "Great Earthquake of 12th June 1897" (1900) and became the chief pursuit of the second half of his working life, subsequent to his retirement from the Survey.

Besides these major works, he was the author of over seventy papers, not only on the results of his stratigraphical, seismological and economic work, but on many branches of physical geography, such as the cohesion of ice and its bearing on glacial erosion, ground-ice, land-slips, the smooth-water anchorages of the Travancore coast, Permian breccias, subterranean water supply, the ancient geography of India, flexible sandstone, facetted pebbles and blown-sand rock sculpture, the action of flowing water, theories of mountain formation, river valleys and rock basins, alleged Miocene man in Burma, the Allah Band of Kachh, sandhills and explosion craters. In Oldham's case versatility did not militate against that thoroughness which is characteristic of all his work. His originality of thought and breadth of vision carried his deductions from observations, far beyond mere description into the stage of elucidating new fundamental laws of science. He was thus the first to recognise (in 1900) the most important principle of seismography, that earthquake waves are split up into and propagated in three distinct forms, with different velocities and different paths, which are received at distant

places as the three well-known phases of the seismographic record. He also deduced (1906), from the records of distant earthquakes, that the earth has a core with physical properties very different from those of the surface shell which we know, and was able to calculate its diameter approximately as two-fifths of the total diameter of the earth. After his retirement from the Geological Survey in 1904 he lived for some time in the Isle of Wight near his friend and fellow seismologist, John Milne, then subsequently at Kew with his unmarried sister until her death, then in winter at Hyères in the south of France, where he made a physiographical and historical study of changes in the Rhone delta since Roman times; in summer he lived at Llandrindod Wells, for the benefit of his health, as he suffered from sprue.

Oldham was awarded the Lyell Medal of the Geological Society in 1908 and was President in 1920-22. He was elected a Fellow of the Royal Society in 1911 and served on the Council of the Society in 1920-21; he was also a Fellow of the Royal Geographical Society, a Member of the Institute of Mining and Metallurgy and an Honorary Fellow of the Imperial College of Science.

A. M. HERON.

NOTES ON THE GEOLOGY OF THE SECOND DEFILE OF THE IRRAWADDY RIVER. BY E. L. G. CLEGG, B.SC. (MANCH.), *Superintending Geologist, Geological Survey of India.* (With Plate 28.)

Introduction.

The 'Second Defile' of the Irrawaddy is probably one of the, if not the, best known beauty spot of Burma. No informed traveller to Burma fails to include the river trip by steamer from Mandalay to Bhamo as part of his itinerary and the best scenic part of this trip is the eight to ten miles in which the river takes a big S-bend from immediately below the Bahmo basin in passing through the craggy heights of the second defile. Despite the popularity of this trip and the indelible impressions of the physical features which remain on all who carry it out, and notwithstanding the popularity of the view of the high crags of the centre of the defile as a guide book illustration, little is known of the geology of the rocks which form it.

It was visited by Griesbach and Nœtling sometime in the early "nineties", as the former[1] speculated on "certain more or less crystalline rocks chiefly limestones which occur in the midst of the metamorphic flexures, and seemingly conformable to the latter" as belonging to the Palæozoic groups and being possibly Silurian in age although actual proofs were wanting and the latter[2] published a map to accompany a "Note on the occurrence of Jadeite in Upper Burma" showing the rocks of the second defile as Silurian (?) Crystalline Limestone.

Since then the defile has been visited only by economic geologists *en route* for an outcrop of lignite which occurs at Lagatyan about four miles due south of Zinbon, a village occurring on the east side of the lower narrows of the defile. It was information derived from one of these—Mr. H. Day of Messrs. Bird and Company—that led to my visit. Mr. Day had informed me that he thought the defile limestones were Palæozoic and I had heard from Burma forest officers that rocks similar to the Mogok limestones occurred in the

[1] *Rec. Geol. Surv. Ind.*, XXV, p. 128, (1892)
[2] *Rec. Geol. Surv. Ind.*, XXVI, p. 26, (1893)

vicinity of Yanbo about fifty miles south of the defile. The physical features of the intervening country seemed to indicate that the hill ranges followed the strike of the rocks and there seemed a possibility of tracing the change in physical character of the rocks of the Mogok series into rocks of Palæozoic age along the strike. My object was to ascertain whether the rocks of the Mogok series were metamorphosed rocks of Palæozoic age or Archæan as had been thought.

Situation and physical features.

The defile proper lies between the villages of Sinkan (24° 9′ : 97° 0′) and Naungmo (24° 8′ : 96° 55′) the former on the left bank at the head of the defile and the latter on the right bank at the foot. One village, Zinbon, is situated in the defile about two miles from the lower end and is possessed of a well-kept forest rest house. The rest house stands on a small hill at the western end of the village; its position is ideal; it looks well from the river but it is even better than it looks. As it lies on the concave bank of one of the big bends of the river, excellent views of the river are obtainable from it both up and down stream, up-stream for about two miles, down-stream for about six miles. There are two bed-rooms and the verandah on which the traveller lives is large and is always cool, owing to the bungalow catching any wind that blows, as a valley opens out from the defile to the south-west.

The scenery is grand. Below Zinbon, that is, between Zinbon and Naungmo, high limestone cliffs form precipitous banks on either side and are very much undercut by solution weathering. Behind Zinbon a narrow flat-bottomed valley accommodates the last half mile of the Zinbon *chaung*; on the east of this valley are steep forest-covered slopes and knife-edged spurs; on the west is a plateau with a 200 feet precipice as its eastern boundary. The recent rocks forming this plateau have at one time continued across the river and a similar plateau occurs on the other side set back just a little from the river bank. Where the Zinbon *chaung* enters the river a small delta juts out into the main stream and forms a landing for the Irrawaddy ferry steamer if cargo justifies it; otherwise the odd passenger to Zinbon is landed by village dug-out or steamer dinghy. Further up the river and about two miles north-east of Zinbon, high limestone cliffs rise nearly a thousand feet sheer from the water, whilst nestling at the base is a most attractive little pagoda perched on a slipped block of limestone. Hence, lower banks

predominate up-stream until the last mile is reached, where once again high limestone rocks form precipitous banks on either side. These terminate abruptly to the east where the defile opens out into the Bhamo plain.

Geology.

The rocks of the defile consist of the following series in descending order:—

(A) Sandstones, calcareous sandstones with intercalated conglomerates.	Late Tertiary sediments.
(B) Serpentines [seen intruded into (C) and (E)].	Intrusives.
(C) Calcareous sediments—limestones, indurated sandstones and shales.	Cretaceous series.
(D) Arenaceous sediments—fossiliferous rubbly sandy strata, the fossils remaining only as ferruginous internal casts.	Cretaceous series.
(E) Older indurated series very much folded and disturbed.	Older sedimentary series.

Oldest sediments.

The oldest sediments form the high ridge consisting of steep forested slopes with knife-edged spurs which runs south from the defile immediately east of Zinbon. They are very much broken and consist of slates, quartzites and numerous volcanic rocks, including quartz-porphyries. Their age is doubtful as they are unfossiliferous but they continue southwards into the ridge of Tangte Hill which consists of rocks having all the physical characteristics of the Chaung-Magyi series, but as Tangte Hill as a whole forms an inlier in Tertiary sediments that is as much as can be said of them.

On the foreshore east of Zinbon chocolate and fawn-coloured rubbly shales outcrop in the river and either underlying or intercalated in these about half a mile east of the village is a bluish grey, almost schistose, fine-grained rock consisting of very much crushed grains of quartz, orthoclase and plagioclase felspars, a little irregularly distributed biotite, and small cubic crystals of iron ore becoming limonitised. The groundmass is microcrystalline and the original character of the rock was probably of a fine-grained gritty nature.

The path from Zinbon to Sinkan turns south from the river 1½ miles east of Zinbon at an occurrence of serpentine which has a

brecciated rock on its western margin. To the south, rocks whose physical characteristics led me to class them as Chaung Magyis occur on the western flank of the serpentine. Where the 1,000 foot contour crosses the path, a chocolate-coloured shaly series similar to that seen on the foreshore occurs. It is difficult to know of what these chocolate-coloured shales consist. They are weathered, unfossiliferous, and appear much softer than the series. I have designated them Chaung Magyis; it is possible they are the remains of a much later series unconformably overlying them.

Cretaceous series.

The arenaceous sediments of the Cretaceous series are fossiliferous and occur from a third to half a mile west of Zinbon on the left bank of the river and are separated from the more calcareous sediments to the west by a hiatus in the sequence. They consist of dark, rather cleaved ferruginous mudstones, are very rubbly and have harder more sandy bands intercalated in them. The fossils occur as ferruginous casts but an *Orbitolina* which determines their age as Cretaceous has been isolated by Dr. Sahni from among them. On the point half a mile E. N. E. of Zinbon they are folded into a syncline. These sediments may be cut off from the harder and more massive Cretaceous rocks to the west by a fault, since Dr. Sahni has recently isolated an *Orbitolina* from the massive limestones; also the two formations may probably be in normal sequence, but similar Cretaceous sediments containing foraminiferal limestones apparently underlie massive limestones similar to those of the defile both near Mesan 10 miles to the S. S. W. and at Yanbo fifty miles to the S. S W.

Calcareous sediments.

The more calcareous part of the Cretaceous series is partly metamorphosed and consists of indurated limestones, sandstones, shales and their infinite combinations. These sediments as a whole dip N. N. E. and, with the exception of the reach which runs from Zinbon for 1½ miles to the east, embrace the whole of the defile; the massive limestones of the series, which in places appear nearly 2,000 feet thick, form the precipitous banks, the more arenaceous sediments the jungle-covered slopes. The limestones have been extremely fossiliferous and the remains of what appear to be large molluscan shells protrude from the limestone rock in a most aggravating manner, as attempts to extract them are unavailing. Their occurrence is terminated at the lower end of the defile by

serpentinous intrusions. East of these serpentines the sediments are all very indurated, contorted and fractured and sometimes almost slaty. Bands of purer limestone occur in them, one on the right bank, about ten feet thick, dips N. N. W. at 70°. Approaching the main limestone band from the west on the right bank, contortions are seen to occur and the brecciation of the massive limestone seems to point to thrusting along the boundary. The contortions might on the other hand be due solely to incompetence in a more elastic series, as on the left bank half a mile south by east of Naungmo a band of almost pure limestone can be seen during the low-water season folded into a syncline.

Naungmo (24° 8′ : 96° 55′) to Zinbon (24° 7′ : 96° 56′). Calcareous sediments.

Only a general correspondence can be made out between the massive limestones on either bank of the river; on the right bank about 1,200 feet of limestone occurs in three main bands, the upper two being each about 300 feet thick and the lower 600 feet; on the left bank about 550 feet of limestone occurs in one band, apparently dipping N. N. W. by W. at 70°. Whether this lack of correspondence is due to normal faulting, or local faulting due to undermining by solution-weathering, it is not possible to say. It certainly does not seem possible for such thick bands to have petered out so much in the 600 yards which separates them. The limestone is all grey, fine-grained and argillaceous in character and is apparently all fossiliferous. So too are the intercalated calcareous shales. Underlying the massive limestone on the right bank are very mixed contorted strata. The limestone so far as can be seen dips north-west at 70°; contorted sediments are squeezed right under it at the junction and the boundary looks far from normal. For about 100 feet to the east of the boundary arenaceous rocks, which appear to be fairly regular, occur but pass eastwards into contorted mixed calcareous strata; they dip N. N. W. at 70°. Remote from the river these contorted rocks are overlain by horizontal late Tertiary sediments. On the left bank the massive limestone is underlain by mixed calcareous and arenaceous beds in which the more calcareous bands are up to thirty feet in thickness; they strike E. N. E. and are almost vertical. Further to the east no exposures can be seen for a short distance and then cleaved, rubbly, ferruginous, fossiliferous, sandy shales of Cretaceous age occur as a syncline on an E. N. E. strike.

Two miles north-east by east of Zinbon the same sediments are met with apparently on the continuation of the same line of strike. On the right bank, debris of the series from the heights to the north occurs along the river from half a mile E. N. E. of Zinbon, the only *in situ* exposures that are seen being the northerly continuation of the serpentines occurring $1\frac{1}{2}$ miles east of Zinbon. Limestone debris overlies these serpentines and continues along the bank to the main massive limestone exposure which forms the grandest feature of the defile. The cliffs are practically sheer for a thousand feet; they consist of bedded limestones, shaly in parts, and dip at low angles (20°–30°) at the south end, steepening to 45° at the north end; they are fossiliferous and bands of shelly limestone are clearly visible weathering out in the undercut cliffs near water-level. All attempts at obtaining identifiable specimens, however, proved unavailing. A huge fallen block provides a foundation for a small pagoda at the base of the cliff, but to realise the size and height of the block one needs to sail close along the bank in a dug-out; it cannot be appreciated from the deck of a passing steamer. On the left bank the only solid rocks seen north of the serpentine are limestones similar to those on the opposite bank and must be almost covered when the river is high; they dip N. N. E. at 25°, form no marked feature and most probably have been locally faulted from the sediments opposite by solution-weathering. Where the limestones cease at the upper end on the right bank they are underlain by ferruginous schistose shales which consist of very fine-grained quartz in a clayey ferruginous matrix. Contortions occur in the latter about 100 yards from the limestone and then the series takes on the strike seen below Zinbon; the dips are however less steep (about 40°). On the left bank opposite to the north end of the limestone outcrop, slaty shales dip S. S. E.; they are isolated from other exposures and their relations cannot be made out. North-east of the main limestone outcrop, the river follows the strike of the rocks to Pt. 386 on the one inch to the mile map where limestone concretions occur in the more arenaceous part of the sediments and limestone debris is found at the mouth of a small stream which there debouches into the main river. At the point just beyond and to the south a tough siliceous brecciated ferruginous rock occurs. Under the microscope this rock is seen to consist of a microcrystalline aggregate in which angular pieces of clayey ferruginous products

Limestones of the middle of the defile.

occur, the whole being split up by fine ramifying quartz veins. It appears to have the true characteristics of a fault-breccia in texture and strikes across the river with the sediments, occurring also on the other side. Intercalated in it on the right bank is a much fractured and broken micaceous grit consisting of angular grains of quartz and subordinate felspar in a microcrystalline indeterminate matrix in which a little biotite and muscovite are present. It is underlain by contorted calcareous rocks consisting of fine-grained quartz and a little felspar in a calcareous matrix dipping north-west at 40°. In these, lower in the sequence, purer limestone bands occur and occasionally a little contortion can be seen. On the left bank of the river, although a general correspondence with the opposite bank can be made out in the lower part of the series intervening between the breccia and the massive limestones of the eastern end of the gorge, in the upper part the rocks appear to be metamorphosed grits and conglomerates although limy bands do occur. One such 3¼ miles north-east of Zinbon is a grey patchy rather dolomitised looking rock. Under the microscope it was found to consist of grey fine-grained granular dolomite with larger patches which give a rather porphyritic look to the rock.

Ferruginous siliceous breccia.

The rocks described appear to overlie the massive limestones of the eastern end of the defile but the relations at the actual boundaries are far from clear. One is not however likely to get clearer sections remote from the river. The massive limestones last mentioned form precipitous banks; at the eastern end they are very much brecciated and on the right bank terminate abruptly where a 20-foot serpentine dyke running north and south occurs. On the left bank the limestones form the high peak (1985) south of the river. Shaly intercalations occur in the limestone series and on the left bank one very clear case of faulting can be seen. On the right bank, near the eastern end of the limestone occurrence, cleaved shaly calcareous strata occur as a dyke about three feet thick in the massive limestone; on the left bank the limestone has not the abrupt termination of that opposite, and metamorphosed shaly rocks apparently underlie it.

Massive limestones of the upper end of the defile west of Sinkan (24° 9′ : 97° 0′).

The limestones on both sides of the river dip north-west at high angles although in places, owing to the jointing, the dip appears to be much less. Stringers or thin bands of fossiliferous strata

and concretions occur and it is only from these that the true bedding can be arrived at. The disturbance of the overlying more sandy strata is well seen at the contact on the left bank.

Large scale mapping is really desirable in country such as this. The one-inch map fails to give a true idea of the inaccessibility of the country bounding the defile, whilst thick forest growth on all but the limestone scarps renders, remote from the river, the finding of one's position an almost impossible task. However, from the detail that I have been able to include, it appears obvious that the limestones of the lower and upper parts of the gorge are one and the same but are separated by faulting which bounds the main exposure in the centre of the gorge on its eastern flank. The eastern is the downthrow side of this fault but mapping of the outcrops in contiguous areas will be necessary before the direction of the fault can be specifically delineated.

On my first casual glance at the rocks of the gorge I thought the upper and lower limestones formed the northerly pitching ends of anticlinal structures; subsequent mapping showed however that this was not the correct interpretation.

Late Tertiary sediments.

Tertiary sandstones overlie the Cretaceous series at Zinbon and form the plateau-like high ground which lies to the west of the Zinbon-Lagatyan track and that which fills in the bay in the older series on the right bank of the river north-east of Zinbon. The forest rest house at Zinbon is built on slipped blocks of ferruginous conglomerate from the same rocks. The series is a very mixed one, as can be seen on the old overgrown track from Zinbon to Shwegu; it consists of fawn sandstones, flaggy calcareous sandstones, occasional white kaolinised sandstones and hard conglomerates with quartz pebbles up to four inches in diameter. Sometimes laterite caps the surface of the series. Along the stream which the path mentioned follows at the junction near Pt. 559 thick conglomerates containing pebbles of quartzite, slate and igneous rocks occur. Soft grits looking very like Irrawaddians of the type exposures overlie these conglomerates, whilst immediately north of Pt. 559, rubbly shales and soft sands and conglomerates dip south-south-west at 15°. A quarter of a mile east of Pt. 559 coarse conglomerates overlie a series of rubbly bluish shales and fine sandstones in which other thin (2 inch) conglomeratic bands occur. They dip S. S. E. at about 20°. Higher up the same stream near

Pt. 867 there is a cliff 100 feet high of practically horizontal conglomerates and intercalated sands and grits. Nowhere did I see any fossiliferous horizons in this series. The series is most certainly unconformable to the older rocks previously described; they have a much greater extent to the south and apparently previously had a much greater one still as a covering of the 'defile' rocks. They also occur as a series of conglomerates, sandstones and shales below the defile, and I noted in travelling down the river a gentle anticlinal fold in them along the right bank between Naungmo and Shwegu.

Above the defile they occur to the east of the serpentine dyke, which terminates limestones of the upper defile on the right bank, as a series of soft sands, whitish and fawn in colour, dipping north-west at 70°. Shales and hard sandstones are intercalated in them and the whole are overlain by recent alluvium.

Intrusive rocks.

Igneous intrusive rocks, now mostly altered to serpentine, terminate the Cretaceous series abruptly on both banks of the river at the lower end of the defile and the limestones on the right bank at the upper end: they also occur flanking the oldest sediments in the middle of the defile 1½ miles east of Zinbon and continue across the river to the north-west. Nowhere were they found intruded into Tertiary rocks either in the 'Second Defile' or to the south.

Specimens from the more unaltered parts of the intrusion at the lower end of the defile seem to point to an original doleritic rock; one, a dark bluish green medium-grained rock, consists of kaolinised plagioclase felspar, hornblende and interstitial quartz, the hornblende showing alteration to chlorite and iron ore; another, a medium-grained dark rock, consists of an interlocking aggregate of olive green hornblende and kaolinised plagioclase felspar; whilst still another consists of an ophitic mass of kaolinised plagioclase felspar, colourless amphibole and epidote, and is much speckled with iron pyrites.

On the spurs which run eastwards to the stream from the Zinbon-Sinkan track 1½ miles east of Zinbon and in the bed of the stream itself only altered igneous rocks are seen. A specimen from an exposure of light-coloured medium-grained chloritic rock consists of idiomorphic crystals of oligoclase, orthoclase and microcline, all rather kaolinised, in a matrix of chlorite; another, a fine-grained rock, consists of kaolinised indeterminable felspars, chlorite and colourless hornblende and might originally have been a dolerite.

In general, though, in this as in all the exposures, only dark green serpentine is encountered.

EXPLANATION OF PLATE.

PLATE 28.—Geological Sketch map of Second Defile of Irrawaddy river below Bhamo. (Scale 1 inch = 1¼ miles, approximate.)

DISCOVERY OF *Orbitolina*-BEARING ROCKS IN BURMA: WITH A DESCRIPTION OF *Orbitolina birmanica*, SP. NOV. BY

M. R. SAHNI, M.A. (CANTAB.), D.SC. (LOND.), D.I.C., *Palæontologist, Geological Survey of India.* (With Plates 29 and 30.)

CONTENTS.

INTRODUCTION.

During the course of his work on the geology of the Second Defile of the Irrawaddy river and the area around Mesan, ten miles to the S. S. W., and near Yanbo, fifty miles to the S. S. W., Mr. E. L. G. Clegg, Superintending Geologist, discovered certain fossiliferous horizons, the age of which, on the available field evidence alone, remained in doubt. Mr. Clegg, therefore, kindly sent the fossils to me for determination and the present paper is the result.

Resumé.

Briefly it may be stated that (1) the fossil determinations prove the occurrence of *Orbitolina*-bearing rocks in Burma. As far as we know, this is the first record of that genus in the Burmese region, the first record in fact of indisputable Cretaceous sediments in that area. The only other occurrence of supposed Cretaceous rocks in Burma is in the Arakan Yoma, but it has been disputed whether the rocks are of Cretaceous or of Triassic age[1]. Tipper records that *Cardita beaumonti*, d'Arch., a species characteristic of the Danian, occurs in these beds, but

[1] Tipper, G. H., *Rec. Geol. Surv. Ind.*, XXXV, p. 119, (1907), and Theobold, W, *Mem. Geol. Surv. Ind.*, X, Pt. 2, p. 134, (1873).

the Axials are clearly a mixed group. (2) A new species in itself not being a satisfactory index to the age of the beds in which it occurs one must rely upon morphological comparisons with other forms for this purpose. Comparison of *Orbitolina birmanica* with orbitolines from the Tibetan region appear to indicate that a lower Cretaceous (probably the uppermost Barremian) age may be assigned to at least a part of the *Orbitolina*-bearing rocks of the Second Defile and the neighbouring area. (3) These comparisons further prove the extension of the Tibetan Lower Cretaceous sea into Burma, which is of importance from the palæogeographical view-point.

Stratigraphical sequence.

According to Mr. Clegg, the rocks of the defile consist of the following series in descending order[1] :—

(A) Sandstones, calcareous sandstones with intercalated conglomerates.

(B) Serpentines [intruding into (C) and (E)].

(C) Calcareous sediments,—limestones, indurated sandstones and shales.

(D) Arenaceous sediments,—fossiliferous rubbly sandy strata, the fossils remaining only as casts.

(E) Older sedimentary series,—older indurated series very much folded and disturbed.

The topmost beds (A), resting unconformably upon the older rocks, are entirely unfossiliferous and a Tertiary age is assigned to them by Mr. Clegg on lithological considerations and field evidence.

Arenaceous sediments.

The rubbly sandy strata (D), occurring at the following localities[2], have been examined:—No. 33, one mile south-west of Mesan (24° 1′ : 96° 52′), sheet 92 D/16; Nos. A, 42 and 43, half a mile north-west by west of Zinbon (24° 7′ : 96° 56′). Specimen No. 29 (only a fragment) from two miles S. S. E. of Mesan (24° 0′ : 96° 53′) Forest Rest House, is lithologically identical to the others but contains no fossils. All these contain profuse remains of molluscan shells in the form of crushed fragmentary casts barely fit even for generic determination. Amongst these, fragments of shells may possibly be referred to the genera *Corbula*, *Trigonia*, *Nucula* and *Pecten*.

[1] *Rec. Geol. Surv. Ind.*, 71, Pt. 4, p. 352, (1937).

[2] The numbers refer to Mr. Clegg's field numbers painted on the specimens.

As previously reported[1], lithologically these beds are similar to those of the Assam Cretaceous placed in the upper division (Senonian) of that system by Spengler[2]. In fact the similarity is so great that had the writer not been able to isolate a single specimen of *Orbitolina*, which appears to be identical with *Orbitolina birmanica* described below from the associated limestones occurring in the Second Defile and elsewhere, a provisional correlation of these beds with the Senonian strata of Assam would have suggested itself. But the genus *Orbitolina* extends in range from the Lower Cretaceous to the base of the Upper Cretaceous only. It does not occur in rocks of younger age than the Cenomanian, that is, the lowermost division of the Upper Cretaceous. As will appear from what follows by comparison with other forms, the *Orbitolina* in the series (D) is assigned to the Lower Cretaceous.

Age of the Calcareous sediments.

In the other fossiliferous series (C), as aptly stated by Mr. Clegg, fragments of fossils protrude in a most 'aggravating' manner from the limestones. But in no case could anything definitely identifiable be recognised in the field. In the face of this it was perhaps natural, on the basis of field evidence alone, to assign these limestones to the Palæozoic, attaining as they do a thickness of 2,000 feet in places, which is rivalled only by that of the massive Palæozoic Plateau Limestones of Burma and the Shan States. Several thin sections examined by the writer equally failed to reveal fossil evidence that would throw light on the question of their age. The discovery of two or three specimens of *Orbitolina* in these massive limestones by the process of heating and sudden cooling whereby specimens became partially detached from the embedding matrix is, therefore, significant. In view of the paucity of material from these massive limestones, detailed comparison of internal structures are not possible, but externally the specimens isolated from samples collected at No. 6, Ku Taung (23° 24' · 96° 5'), sheet 93 A/3, appear to be identical with the larger microspheric individuals of *Orbitolina birmanica* from No. 20 $\frac{3}{4}$ mile due north of Yanbo (23° 41' : 96° 41'), sheet 93 A/10, and No. 21, Maingtha Chaung (23° 44' : 96° 42'), sheet 93 A/10. One of the specimens from the massive limestones is figured in text-figures *e* and *f* and may be compared with figures *g* and *h* respectively, from near Yanbo. No

[1] *Rec. Geol. Surv. Ind.*, 71, Pt. 2, p. 169, (1936).
[2] *Pal. Ind.*, N. S. Vol. VIII, Mem. No. 1, pp. 1-73; Pls. I-IV, (1923).

megalospheric individuals, which in rock samples from Yanbo and Maingtha Chaung occur in about the same proportion as the microspheric, have been found in the samples from Ku Taung, though only a few blocks could be examined. On the available evidence therefore beds (C) and (D) should both be assigned to the lower Cretaceous, which means a great thickness of these sediments in this area.

With regard to the Calcareous sediments (C), this statement is made with some reserve as the writer feels that lack of sufficient material does not give complete confidence in expressing a conclusive opinion. However, the fact of their Cretaceous age cannot be doubted, especially as further evidence has become available since this paper went to press. Thin sections of specimen No. 59, from the right bank of the Irrawaddy river (24° 9′ : 96° 59′), 4½ miles E. N. E. of Zinbon, sheet 92 D/16, examined by the writer and definitely referred by Mr. Clegg to his Calcareous sediments, have conclusively proved the presence of *Orbitolina,* though the majority of specimens are crushed almost beyond recognition. Their specific identification is therefore not possible, but from their general characters (such as are available for examination in portions of isolated specimens that have partially escaped crushing) their identity with specimens from Ku Taung in the area to the southwest may be considered fairly certain.

The chief interest of specimen No. 59 from the Calcareous sediments is that it is the only specimen from the Second Def le which has yielded *Orbitolina* and has, therefore, enabled the writer to assign a Cretaceous age to the great thickness of the massive limestones of the Defile proper which are included by Mr. Clegg in his Calcareous sediments (C). The remaining specimens from the Calcareous sediments of the Defile noted in the following list and examined by the writer did not yield any orbitolines :—

Specimen No. 44	Irrawaddy river (24° 7′ : 96° 55′). One mile north-west by west of Zinbon (left bank). Sheet 92 D/16.	Grey, fine-grained, rather argillaceous limestone.
„ „ 52	Irrawaddy river (24° 8′ : 96° 57′). Two miles north-east of Zinbon (right bank). Sheet 92 D/16.	Crushed grey limestone, weathering to a dul black colour.

Specimen No. 53	Irrawaddy river (24° 8′ : 94° 57′). Two miles north-east of Zinbon (right bank). Sheet 92 D/16.	Dark grey, fine-grained limestone with calcite veins.

In addition the following specimen from the Calcareous sediments of the area ten miles to the S. S. W. of the Defile showed no trace of orbitolines :—

Specimen No. 35	One mile S. W. of Mesan Forest Rest House (24° 1′ : 96° 52′). Sheet 92 D/16.	Dark grey compact fossiliferous limestone.

The absence of orbitolines in the above noted specimens may, however, be due to paucity of material available for examination, to unsuitable conditions or to effects of crushing and recrystallisation, and does not necessarily imply that foraminifera did not exist in these rocks.

One could have wished that the fossil collections from these horizons were somewhat better and more extensive. But their paucity was inevitable, as the collections were made during the course of a traverse across a comparatively wide area. Considering the importance of the area it is very desirable that extensive collections should be made in order to elucidate more clearly the relationship and ages of the different formations.

We now come to the important question of the relative ages of the Calcareous sediments (C) and the Arenaceous sediments (D) of the Cretaceous series. According to field evidence the possibility of a fault between the two formations was suspected by Mr. Clegg. The presence as far as we know of the same orbitoline in the two formations appears to indicate that these are in normal sequence.

There is another point to which attention may be drawn. Mr. Clegg mentions certain volcanic intrusions into the Calcareous sediments (C) and the Older sedimentary series (E)[1]. On the basis of the present determinations (C) is younger than series (D), and it is suggested that further examination will reveal the presence of similar intrusions in beds (D) also. In the areas mapped by the writer in the Northern Shan States, no intrusion into rocks of younger ages than the Chaung

[1] *Loc. cit.*, p. 352.

Magyis, which correspond to series (E) of Mr. Clegg, are known. The massive thickness of the overlying pre-Cretaceous Mesozoic sediments and the Plateau limestones is entirely devoid of volcanic intrusions.

Incidentally it may be mentioned that Mr. D. N. Wadia[1] discovered a series of *Orbitolina*-bearing beds in Kashmir interbedded with a great thickness of volcanic rocks, which may be compared with the *Orbitolina* beds of Burma, now under consideration. Unfortunately, lack of time has not permitted the study of the relationship between the Kashmir and Burma orbitolines.

II.—DESCRIPTION.

Sub-family : *ORBITOLININAE.*

Orbitolina birmanica, sp. nov.

Holotype.—G. S. I. Type No. 16345.

[Plates 29 and 30 and text-fig. 1.]

Although a large number of specimens has been isolated, only a single species appears to be represented in the samples from near Yanbo, Maingtha Chaung and Ku Taung. Both microspheric and megalospheric forms are represented in profuse numbers at the first two localities, but the proportion of microspheric individuals is slightly greater.

I.—External structure.

Microspheric form.—The microspheric individuals are depressed conical with a prominent central boss or mamilla from which the test slopes at first rapidly, then gently, to the fairly sharp margin (which shows a scarcely perceptible tendency to curve upwards) in the characteristic shape of a Chinese straw hat. The shell is irregularly circular in outline and slightly wavy (Plate 30, figs. 7-11, 17, and 19). The lower surface is concave, the degree of concavity varying to a certain extent. (Compare Plate 29, fig. 1, and Plate 30, figs. 1 and 2). The specimens are on the average about 5 mm. (or slightly less) in diameter but considerably larger individuals are known—the largest so far isolated being 13 mm., that is, nearly

[1] *Rec. Geol. Surv. Ind.*, LXVIII, pt. 4, p. 419, (1935).

half an inch across (Plate 30, figs. 9, 9*a*). Specimens of intermediate sizes have also been isolated. The largest specimen measures about 3 mm. in height, but the average height is not more than 2 mm.

Unfortunately, only a single specimen, out of the very large number isolated, shows the concentric lamellæ (Plate 29, fig. 7) and even in this the condition of the test is not such as to permit accurate measurements of the distance separating these.

Megalospheric form.—The megalospheric individuals are distinctly conical (Plate 30, figs. 12·16), the apex subtending, as in the corresponding form of *Orbitolina tibetica*,[1] Cotter, an angle of almost 90°. The maximum diameter of the base is about 4 mm., the height varies from 2 mm. to 3·5 mm. All the distinctly conical ndividuals are without the central boss or mamilla and the lower surface is either flattened or convex, the degree of convexity varying to a certain extent.

II.—Internal structure.

The internal structure of *Orbitolina* has been studied in some detail by Carter[2], Carpenter[3] and Fritsch[4] (who both referred certain species of *Orbitolina* to *Patellina*), by Martin[5] and more recently in concise detail by Douvillé[6]. Fortunately on account of the large amount of available material and by comparison with the already published studies, it has been possible to elucidate the internal structure of the Burmese species also in some detail. Plate 29, fig. 5, is a transverse section through a megalospheric (but somewhat depressed) form showing septa disposed in a regularly radiating manner along the periphery, but becoming irregular towards the central region. Plate 30, fig. 5, is a tangential section through another highly conical individual, parallel to and near the outer surface of the shell, that is the region where the septa are regularly disposed. The section is incomplete—the shell having been damaged in the course of preparation of the section. Plate 29, fig. 6, is another oblique section through a distinctly conical but relatively broader individual.

[1] *Rec. Geol. Surv. Ind.*, LXI, Pt. 4, p. 352, (1929).
[2] *Ann. Mag. Nat. Hist.*, Ser. 3, Vol. VIII, pp. 458-460, (1861).
[3] Introduction to the Study of Foraminifera, pp. 229-235, (1862).
[4] *Palæontographica*, Suppl. III, Lief. I, pp. 144-145, (1875).
[5] *Sammlungen des Geologisches Reichs-Museum in Leiden*, Vol. IV, pp. 209-229, Pls. XXIV and XXV, (1884-1889).
[6] *Bull. Soc. Geol. France*, 4me Ser. Tome quatrienne, pp. 653-661, Pl. XVII, (1904).

The internal structure of the microspheric forms is identical to that of the high conical megalospheric forms except for the fact that in the former the transverse sections pass through several chambers and therefore become more complicated. Plate 29, fig. 2, is a transverse section through a microspheric form passing well above the basal surface. It passes through several chambers and shows a similar disposition of septa to that in the corresponding section of the megalospheric individual. The zigzag character of the septa, to which Douvillé and others have drawn prominent attention, is better seen in the darker part of the figure. The central portion represents the concavity of the lower surface filled with extraneous material. Plate 30, fig. 4, represents a transverse section, very close to the basal surface. The outer imperforate lamina and the supporting mesh structure are not seen in this section, but the quardrangular cells arranged in concentric circles, along the peripheral region, giving place towards the centre to triangular cells, similarly arranged, are clearly visible. The central dark area represents the basal concavity filled with extraneous material. Plate 29, fig. 1, and Plate 30, figs. 1 and 2, are vertical sections through microspheric individuals, the latter two passing through the central boss. Plate 30, fig. 6, is an enlargement of a portion of the specimens figured in Plate 29, fig. 2. All the sections show several minute foreign bodies dispersed through the shell structure. Martin[1], Cotter[2] and others have drawn attention to these in the case of the specimens from Borneo and Tibet studied by these authors respectively. The foreign bodies in *Orbitolina birmanica* consist both of quartz and calcite. These foreign bodies, '*fremdkorporschen*' of Martin, are clearly seen in Plate 30, fig. 6, which is magnified sixty-four times.

III.—AFFINITIES AND COMPARISON.

In structural characters the present species resembles *Orbitolina tibetica*, Cotter. The shape of the microspheric forms, however, is different in the two species. In *O. tibetica* 'the upper surface has a central boss which spreads into a saucer shaped disc'.[3] In *Orbitolina birmanica*, on the other hand, the shell slopes from the central

[1] *Loc. cit.*, p. 227, Pl. XXIV, figs. 10-12.
[2] *Loc. cit.*, p. 352.
[3] Cotter, G. de. P., *Loc. cit.*, p. 352.

boss to the margin which is scarcely upturned so that the boss is visible in lateral views, which is not always the case in *O. tibetica*.

The distinction is well illustrated in text-fig. 1. The megalospheric forms are very similar in both cases.

The concentric lamellæ in *O. birmanica* are not seen except in one specimen only (Plate 29, fig. 7), so accurate comparison in this respect is not possible between the two species.

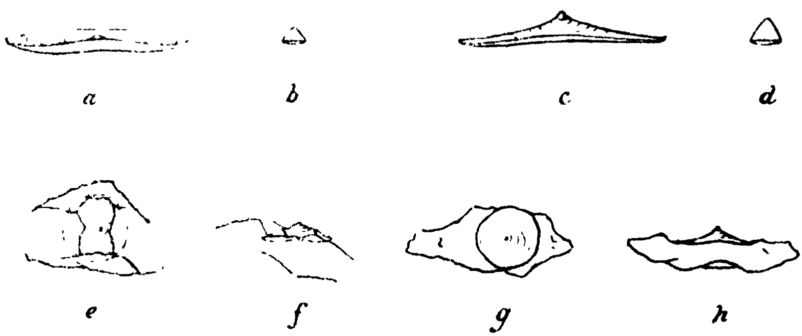


FIG. 1.—(*a*) *Orbitolina tibetica*, Cotter. Microspheric form (Holotype) in lateral view showing the characteristic saucer-like shape (×4). G. S. I. Type No. 14332.

(*b*) Same. Megalospheric form in lateral view. (Nat. size.) Paratype. G. S. I. Type No. 14327.

(*c*) *Orbitolina birmanica*, sp. nov. A comparatively large microspheric individual from near Yanbo, in lateral view. Margin scarcely upturned. (×3). Compare with *O. tibetica*, (fig 1*a*) above. Paratype. G. S. I. Type No. 16349.

(*d*) Same. Megalospheric form in lateral aspect (Nat. size). Compare with *O. tibetica*, (fig. 1*b*) above. Paratype. G. S. I. Type No. 16344.

(*e*) *Orbitolina cf. birmanica*, sp. nov. Reconstruction of imperfect specimen from Ku Taung (Calcareous sediments) in dorsal view. (Nat. size). G. S. I. Type No. 16357.

(*f*) Same specimen, lateral view. (Nat. size).

(*g*) & (*h*) Two views (Nat. size) of specimen figured in (*c*); for comparison with (*e*) and (*f*) respectively.

In external shape the microspheric form resembles *Orbitolina concava* Lamarck, but according to Douvillé[1] the latter does not possess the thick conical form, both the microspheric and megalospheric individuals having the same shape. Distinction from *O. concava*, Lamarck, is, therefore, well marked. Incidentally it may be mentioned that Yabe and Hanzawa[2] consider that 'the specific

[1] *Comptes Rendus*, Vol. CLV, p. 571, (Sept. 1912).
[2] *Science Rep. Tohoku Imp. University, Sendai, Japan*, Second Ser. (Geology), Vol. IX, No. 1, p. 15, (1926).

name *scutum-trochus* given by D. K. Fritsch in an earlier date now seems more applicable' to the form described under *O.* '*concava*' from Borneo by Martin.

The species described from Shushal near Leh by Fossa Manchini[1] as *Orbitolina pileus* and *O. parma* are obviously megalospheric and microspheric forms of the same species. *Orbitolina parma* differs in shape from *O. birmanica*, but resembles *O. tibetica*, being like the latter saucer-shaped. This is clearly seen in Manchini's illustrations.[2] According to Cotter these two forms are distinct on account of the difference in the interspaces separating the concentric lamellea.[3] The vertical section of *O. pileus* given by Manchini shows a highly conical form, much more conical than any of the megalospheric individuals of *O. birmanica* so far isolated by the writer, but Manchini[4] states that intermediate shapes are also found, though these are not figured.

The forms bearing a much closer resemblance to *O. birmanica* are the lower Cretaceous forms from Tibet which Douvillé[5] has compared with *O. bulgarica* and *O. discoidea*. These, according to him, constitute forms A and B of *O. bulgarica* which is characteristic of the Uppermost Barremian.

IV.—CHEMICAL COMPOSITION OF THE TEST.

Chemical analyses.

Some observations on the nature of the test may be made. Although Douvillé mentions that the test in the orbitolines is arenaceous[6], no analyses stating the percentage of silica content are given. Cotter[7] states that the silica percentage in *Orbitolina tibetica* is 5·26. Two analyses of the definitely conical (megalospheric) and the definitely discoidal individuals of *Orbitolina birmanica*, kindly made by Dr. R. K. Dutta

[1] Spedizione Italiana De Filippi nell' Himalaia, Caracorum et Turkestan Chinese, Foraminifere del Calcaire grigio di Scivscivl (tago Pancong), (1913-14), Ser. II, Vol. VI, pp. 107-223, Pls. XXII and XXIII, (1928).

[2] *Ibid*, Pls. XXII, figs. 5 and 6. Pl. XXIII, fig. 4.

[3] *Loc. cit.*, p. 354.

[4] *Loc. cit.*, p. 198.

[5] In Seven Hedin, 'Southern Tibet,' pp. 145-146, Pls. IX, fig. 3; Pl. X, figs. 1-3, Pl. XI, fig. 1.

[6] *Bull. Soc. Geol. France*, 4th ser., Vol. IV, p. 655.

[7] *Loc. cit.*, p. 351.

Roy in the Geological Survey Laboratory, gave the following percentages :—

—	CaO.	SiO_2.	MgO.	Fe_2O_3 and Al_2O_3.
Megalospheric form . . .	43·83	15·30	1·62	5·0
Microspheric form . . .	43·17	14·88	1·47	4·08

The slightly higher percentage of Fe_2O_3 and Al_2O_3 in the microspheric forms may perhaps be accounted for by their lower concave surface in which slight traces of extraneous material would remain adhering to the shell. In other respects the correspondence in the percentages of CaO, SiO_2, etc., in the two forms is quite close, and the two analyses therefore confirm each other.

By comparison with the above table the wide divergence in regard to the chemical composition of the species from Burma and Tibet, which structurally appear to be allied, will be noticed. *O. birmanica* contains 15·30 per cent. silica, whereas according to analyses by Dr. W. A. K. Christie[1] the silica percentage in *O. tibetica* is 5·26, only one-third that in *O. birmanica.*

This confirms the conclusion arrived at by other workers regarding the relative importance of the chemical composition and structural characters of the test in Foraminifera, about which there is considerable divergence of opinion. I quote at length from Davies[2], who referring to Chapman's work on Foraminifera, wrote—

'later it was emphasised that forms within this '*Patellina*' group had arenaceous or sub-arenaceous tests, while others were purely calcareous ; so as Carpenter had already minimised the importance of structural distinctions .... the way was opened for what appears to be an undue emphasis laid upon the chemical composition of the test, to the ignoring of physical structure. Nor is this all for the impossibility of retaining all these types within a single genus has led to re-sub-divisions of the group being made, and we find old generic names are now apt to reappear in impossible connections. Thus Chapman first described certain new forms, which he found near Cairo, as '*Patellina ægyptensis*'[3] ; but afterwards, apparently because he found them to be sub-arenaceous, he referred them to '*Conulites ægyptensis*'[4]'.

[1] In Cotter, *Loc. cit.*, p. 351.
[2] *Rec. Geol. Surv. Ind.*, LIX, pp. 237-238, (1926).
[3] *Geol. Mag.* Decade IV, Vol. VII, p. 3, Pl. II, figs. 1-3, (1900).
[4] The Foraminifera, p. 157, (1902).

Davies has further pointed out[1] that this—

'is manifestly wrong and it is easier to believe that the composition of the test varied in closely allied forms than that morphologically very similar types should be placed far apart on the mere grounds of the chemical composition of the test'.

Similar views have been expressed by Schlumberger and Douvillé[2]. As the question is of importance and much general interest, I may be permitted to quote them in full—

'Les caractères tirés de la *constitution du test* sont d'importance tres différentes ; tandis que tous les naturalistes sont généralement d'accord pour considerer comme un caractére de premier ordre la nature perforée ou imperforee du test, *la composition meme de ce dernier, calcaire ou chitineuse et arénacée, ne parait avoir qu'une importance secondaire.* On constate en effet de grandes differences à ce point de vue dans des formes tres voisines et dont l'étroite parenté n'est pas contestable. Il faut ne voir là qu'un simple fait d'adaptation à des conditions d'existence particulières ; les formes nageuses ont normalement un test calcaire tandis que les formes qui vivent sur le fond sont les seules qui puissent emprunter à ce dernier des matériaux étrangères et les utiliser pour la construction de leur maison : le but poursuivi est bien certainement ici une économie de matière ...... *C'est là un caractère de perfectionnement et qui n'est que secondaire au point de vue de la classification* de formes tres voisines comme les *Alveolina* et les *Loftusia* pouvant présenter les une un test porcelané, les autres un test arenacé et réticulé'.

The differences in the chemical composition of the tests in *O. tibetica* and *O. birmanica* are therefore not such as would preclude their essential affinity in structural characters.

V.—AGE OF THE *ORBITOLINA*-BEARING BEDS OF BURMA.

Orbitolina birmanica being a new species, the question of the age of the *Orbitolina*-bearing beds of Burma must rest either upon comparisons with other forms of known age or upon lithological similarities. The Cretaceous rocks nearest to the *Orbitolina* beds of Burma are those of the Arakan Yoma[3], Assam, Kashmir and Tibet. *Orbitolina* has not been recorded from the former two areas, but it has been recorded both from Kashmir and Tibet. Lithological comparisons between rocks of remote areas cannot be altogether reliable, as we have seen in the case of the Cretaceous rocks of Assam, though in the absence of fossil evidence or field

[1] *Loc. cit.*, footnote, p. 238.

[2] *Bull. Soc. Geol. France*, 4^{me} Ser. Tome V, pp. 291, (1905).

[3] As previously remarked, the presence of undoubted Cretaceous rocks in this area has not yet been proved, though their occurrence there is more than probable.

data, thus remains the only available means of correlation. Comparisons with the other species of *Orbitolina* show that *O. birmanica* is closely allied to the forms referred by Douvillé to *O. bulgarica* from Tibet, which is a Lower Cretaceous (Uppermost Barremian) species. It is allied similarly to *Orbitolina tibetica* which, according to Cotter, is probably of the same age.

On the basis of these comparisons, I would place *Orbitolina birmanica* in the Lower Cretaceous and assign to it a probable uppermost Barremian horizon. This implies the extension of the Lower Cretaceous sea of Tibet into the Burmese region.

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VII.—EXPLANATION OF PLATES.

Orbitolina birmanica, sp. nov.

Holotype, G. S. I. Type No. 16345, the remaining specimens being paratypes.

PLATE 29. FIG. 1. Vertical section through a microspheric form ×16. G. S. I. Type No. 16333.

FIG. 2. Transverse section through a microspheric form passing above the base, showing the regular disposition of septa near the periphery, becoming irregular towards the central region. ×16. G. S. I. Type No. 16334.

FIG. 3. Vertical section through a megalospheric form with a convex base. ×16. G. S. I. Type No. 16335.

FIG. 4. Similar section through another slightly broader individual. ×16. G. S. I. Type No. 16336.

FIG. 5. Transverse section through a somewhat depressed megalospheric individual. ×16. G. S. I. Type No. 16337.

FIG. 6. Oblique section through a megalospheric individual. ×16. G. S. I. Type No. 16338.

FIG. 7. Upper surface, showing exposed concentric lamellæ. ×16. G. S. I. Type No. 16344.

PLATE 30, FIG. 1. Vertical section through a microspheric form. ×16. G. S. I. Type No. 16339.

FIG. 2. Similar section through a relatively more conical microspheric form passing through the central boss. ×16. G. S. I. Type No. 16340.

FIG. 3. Vertical section through a megalospheric form with damaged lower surface. ×16. G. S. I. Type No. 16341.

FIG. 4. Transverse section through a microspheric individual, passing very near the base. ×16. G. S. I. Type No. 16342.

FIG. 5. Oblique section through an incomplete megalospheric individual. ×16. G. S. I. Type No. 16343.

FIG. 6. Portion of specimen figured in Plate 29, fig. 2, enlarged showing foreign bodies. ×64. G. S. I. Type No. 16354.

FIGS. 7, 7*a*. Microspheric form. ×2. G. S. I. Type No. 16344.

FIGS. 8, 8*a*. Microspheric form. ×2. G. S. I. Type No. 16345.

FIGS. 9, 9*a*. An exceptionally large microspheric individual. ×2 G. S. I. Type No. 16346.

FIGS. 10, 10*a*. Microspheric form. G. S. I. Type No. 16347.

FIGS. 11, 11*a*. Young microspheric form. G. S. I. Type No. 16348.

FIGS. 12, 12*a*. Dorsal and lateral aspects of a megalospheric individual representing an almost perfect cone. G. S. I. Type No. 16349.

FIGS. 13, 13*a*. Dorsal and lateral views of a megalospheric individual ×2. G. S. I. Type No. 16350.

FIGS. 14, 14*a*. Dorsal and lateral aspects of a megalospheric form showing convex base. ×2. G. S. I. Type No. 16351.

FIGS. 15-16. Similar views of two megalospheric individuals. ×2. G. S. I. Type Nos. 16352 and 16353 respectively.

FIGS. 17-19. Dorsal views of three microspheric individuals. ×2. G. S. I. Type Nos. 16354, 16355 and 16356 respectively.

NOTE ON ROCKS IN THE VICINITY OF KYAUKSE, BURMA. BY E. L. G. CLEGG, B.SC. (MANCH.), *Superintending Geologist, Geological Survey of India.*

In *Memoirs*, Volume XXXIX, Part 2, p. 34 La Touche in discussing the extent of the Archæan rocks states—

'Archæan' rocks of Kyaukse.

'On the eastern bank (*i.e.*, of the Irrawaddy) the Palæozoic rocks of the Shan Plateau come right down to the plains of the Irrawaddy and the Archæan gneisses are found to occur only in a few outlying hills rising abruptly from the alluvium, including the Sagyin hills, mainly composed of crystalline limestone, which is largely quarried as a statuary marble, and Mandalay Hill which consists of the same marble traversed by veins of granite.

The gneisses appear again at the foot of the plateau scarp at Kyaukse, where there are large marble quarries, 25 miles south of Mandalay and beyond this they form a continuous band from 12 miles upward in width along the edge of the Southern Shan plateau, extending to the sea near Moulmein.'

Datta's division of the Kyaukse rocks.

Sheet 93 C/2, which includes Kyaukse, (21° 36′ : 96° 10′) was mapped by Mr. P. N. Datta during the field-season 1911-12. Mr. Datta divides the rocks of the eastern part of this area at the foot of the Shan Plateau north-east and east of Kyaukse town into the following series in descending order—

(1) Sandstones and quartzites—near Belin and between Belin and Kyaukse.
(2) Argillites and Quartzites one mile east of Kyaukse.
(3) Kinnaytaung limestone.
(4) Ubantaung shale.
(5) Datta-taung limestone.
(6) Sindetaung shale.

Of the relationships between (1) and (2) Datta says[1]—

Relationships of the Kyaukse rocks.

'As to the relationships of the sandstones and quartzites of the hills near Belin and between Belin and Kyaukse, as well of the argillites of the Kyaukse range: the argillites, *i.e.*, the shales with sandstone bands since transformed into argillites and quartzites overlie the Kinnaytaung limestone. The sandstones of Indaung, Kyaungywa and Belin would seem to form part of one and the same band and to overlie the Kyaukse argillites. The quartzites two miles E. by N. of Belin either form part of the Kyaukse argillites or of the sandstones of the Indaung hill; and if the latter the Kyaukse shale band had evidently thinned out considerably northwards.'

[1] Field Progress Report, Season 1911-12, p. 11.

Datta was unable to find any fossils in any of the rocks of the sedimentary series but placed them tentatively in the Palæozoic group.

Of the Kyaukse gneiss Datta says[1] :—

'The only outcrop of gneiss occurring in the area under examination is that of the Kyaukse hill (21° 36′ 30″ : 96° 10′ 30″). The question is :—was this crystalline mass originally granite, since altered through earth movements into its present schistose condition, or was it originally intruded as gneiss, converting the adjoining shales and limestones into argillites and marble, etc., pretty much as we see them now ?

Now at the south-eastern extremity of the mass, *i.e.*, by Tanda-u one mile south-east of Kyaukse, the sedimentaries do not exhibit signs of any great earth disturbance, the dips nearest the edge of the gneiss being about 15° (which however is found to increase steadily to 30° as one proceeds along the range eastwards). The Indaung sandstones again (about one mile north of the Kyaukse gneiss) show no indication of any plication or crumpling, but exhibit a steady dip to N. by E. at about 20°. Hence there being in this neighbourhood no indications of any such great disturbance of the earth's crust here as could have converted a granite into a gneiss, it seems that the foliation of the mass was original and not induced later on as a result of subsequent earth movements.'

On April 8th, in the course of a journey to Mandalay, I stopped for a day at Kyaukse and examined the rocks east of the town and also some railway ballast quarries which exist close to the road at Belin, five miles north of Kyaukse.

Of the former Datta states[2] :—

'Near Kyaukse (21° 36′ 30″ : 96° 10′ 30″)—from the very eastern edge of the town rises a precipitous hill which is seen to extend E.—W. as a range for about five miles. The high precipitous hill near the town constitutes the highest part of the range and is formed of a well-foliated felspar-quartz-biotite gneiss bearing the pagoda with the trigonometrical station (height 975 feet), conspicuous for many a mile around. The remainder of the range, *i.e.*, east of this gneissic mass, is composed of indurated micaceous sandy shale, grey thin banded quartzite, argillites, micaceous schist and crystalline limestone. The shale is almost unaltered in places, but in others it has been converted into an argillite and mica-schist. The crystalline limestone is well seen about four miles east of Kyaukse. The dip varies from 15° to 30°.'

Of the latter Datta states[3] :—

'The hill just S. E. of Belin (20° 40′ 30″ : 96° 10′ 30″) is formed of a coarse reddish sandstone rather thick-bedded with a dip of 20° to 30° north by east. On the

[1] Field Progress Report, Season 1911-12, p. 11.
[2] *Ibid.*, pp. 5-6.
[3] *Ibid.*, pp. 4-5.

northern part of the hill we find strings and veins of granite altering the associated rock into a quartzite.

North-east of the village is a high hill striking S. W.—N. E. Its south-western extremity, *i.e.*, the part nearest the village, bears the trigonometrical station 949 feet high and is formed mostly of quartzites, with strings of granite, while the rest of the range is due to granite.'

Kyaukse granite.

The Kyaukse granite or gneiss is undoubtedly intrusive into the series of sedimentary rocks which occur to the east as the strike of the gneissosity bands is north-south, whilst that of the sedimentary series is east-west, their dip being north at about 20°.

Indurated sedimentary rocks of Kyaukse area.

Further, with regard to the sedimentary series, Datta's description of them as argillites and quartzites is not quite correct. Practically all the rocks are calcareous. They consist, 200 yards east of the granite, of a series of well-bedded shaly limestones, very regular in character but with more sandy and shaly intercalations, the whole series weathering like calcareous gneisses. Some of the more solid limy bands have thicknesses up to four feet and the more shaly ones from 6″ to one foot, whilst individual bands of limestone vary from one inch upwards. Close to the granite the shales are phyllitic and at the contact include biotite-schists.

The main exposure of granite consists of quartz, felspar and biotite, large white felspars up to 6″ in length being streaked out along the gneissosity planes into an augen structure. On the flank of the exposure bands of granite contain tourmaline.

Quarrying at Belin was being carried out along the boundary of a granitic intrusion, granite underlying the alluvium to the west and tough metamorphosed calcareous sediments forming the hill to the east and apparently providing but a thin covering to the granite intrusion, as granite forms the main mass of the hill to the north-east. These sediments were of a much higher grade of metamorphism than those seen east of the Kyaukse granite and consisted of white marble, diopside-granulites, hornblende (actinolite)-gneiss and a dark greenish rock rich in epidote and diopside, whilst those east of Kyaukse consisted of calc-sericite-schists remote from the granite and a biotite-gneiss on the contact. The contact was not opened up as at Belin or possibly similar rocks to those at Belin would also have been found.

However that may be, there seems little doubt that Datta was quite correct in regarding the rocks of the area as a series of Palæozoic or later rocks intruded by granites and that La Touche erred in regarding the gneisses as of Archæan age.

Age and correlation of the Kyaukse rocks.

Datta's limestones pass northwards into the Plateau Limestones of La Touche and if the metamorphosed series of calcareous sediments are, as Datta says, younger than the limestones, then the granitic intrusions must be post-Plateau Limestone in age and therefore probably Mesozoic.

A continuation of the strike of the limestones as mapped by Datta in sheets 93 C/2 and 93 C/3 to the south takes them into Plateau Limestones of the Kalaw area in sheets 93 D/5 and 9. Further to the south Sondhi has mapped Coal Measures (Jurassic) overlying the Plateau Limestones in sheet 93 D/7 and granites intrusive into the same Coal Measures in sheet 93 D/12. The possibility exists therefore that the indurated calcareous sediments of the Kyaukse area, which are stated by Datta to overlie the massive limestones, were originally Coal Measures of the Shan States sequence. If this turns out to be correct then the age of the Kyaukse granite must be post-Jurassic.

A MESOZOIC CONIFEROUS WOOD (*Mesembrioxylon shanense, sp. nov.*), FROM THE SOUTHERN SHAN STATES OF BURMA.

BY B. SAHNI, SC.D., F.R.S., *Professor of Botany, Lucknow University.* (With Plate 31.)

CONTENTS.

I.—INTRODUCTION.

The following description is based upon a solitary specimen of silicified wood from the Loi-an series of Burma, kindly sent to me for investigation by the Director of the Geological Survey of India. Although by no means well preserved the specimen is described in some detail because, so far as I know, this is the only coniferous wood hitherto discovered in Burma. A number of vegetative shoots preserved as impressions have been described recently from the same series of strata.[1] The Loi-an series is regarded by the Survey as Jurassic, and the evidence of this fossil is not inconsistent with this view.

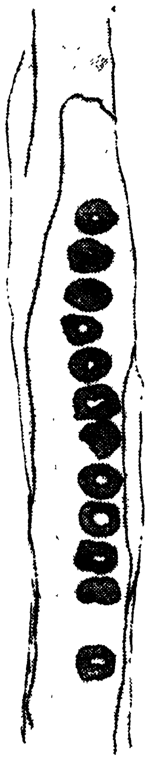
II.—DESCRIPTION.

The specimen is about 5 cm. long and 6·5 cm. in diameter. The pith is very eccentrically placed, but this is probably due to the incomplete preservation of the secondary wood on one side. In a naked eye examination there is a faint suggestion of growth-rings, but these are scarcely visible under the microscope. The pith is well preserved, but the wood shows the pitting only sporadically.

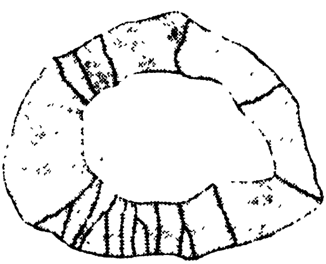
Transverse section.—The pith, 1·6 mm. wide, consists mostly of thin-walled isodiametric cells, among which a number of large

[1] Sahni, B., *Pal. Ind.*, N. S., Vol. XI, Pt. I, (1928), *Brachyphyllum* sp., p. 22, pl. II, fig. 26*a*; *Pagiophyllum burmense*, p. 25, pl. II, fig. 26*b*; pl. IV, figs. 48-51; *Cupressinocladus (? Thuites) walkeri*, p. 26, pl. IV, figs. 52-57, pl. V, fig. 60; *Cupressinocladus burmensis*, p. 28, pl. IV, figs. 58-59.

(1). ×*ca* 310.



(2). ×*ca* 310.



(3). ×*ca* 310.

FIGS. 1—3.—*Mesembrioxylon shanense*, sp. nov.

stone-cells are scattered. About twenty-three primary xylem bundles project as rounded angles into the pith, giving the latter a stellate appearance (Plate 31, fig. 1). The narrowest tracheids are endarch, but their sculpturing is not preserved. The average diameter of the tracheids in the secondary wood is ·03 mm. The preservation is too poor to show in the transverse section of the wood either the pittings of the tracheids or the structure of the medullary rays.

Tangential section. The tangential section (Plate 31, fig. 2) shows that the medullary rays are all uniseriate and as a rule one to two cells high. The highest ray observed is four cells. The cells appear laterally compressed and elliptic in section. No tangential pits have been seen, but the preservation is too bad to make it certain that they were absent.

Radial section. Plate 31, fig. 3 shows a radial section passing through two protoxylem bundles, with the pith between. Portions of the primary metaxylem and the secondary wood are also seen. The thin-walled cells of the pith, as a rule isodiametric, are sometimes considerably longer than broad; they usually have transverse end-walls. The stone-cells are of simple shape and usually about two or three times as large as the ordinary cells of the pith; their walls are moderately thick, leaving a lumen about half the diameter of the cell (Plate 31, figs. 3, 6; text-fig. 3). The sculpturing of the protoxylem is not preserved. The radial pits of the secondary tracheids, rarely preserved, are uniseriate, circular and separate (Plate 31, fig. 4; text-fig. 1). The pore may be either circular, or elliptic and oblique. The pits in the field, visible only in a few medullary rays, are large borderless pits of the type of eiporen, one or at most two in each field (Plate 31, fig. 5; text-fig. 2). Most of the tracheids show a deceptive appearance of thick dark coloured transverse septa; this is due to the presence of quantities of resin which occurs in the form of plates or spools with a convex or concave meniscus (Plate 31, figs. 2, 3). Although it is possible that here and there parenchymatous cells with transverse end-walls may be present, I have not found any undoubted cells of this nature.

Systematic position. The structure of the wood corresponds most nearly to the diagnosis of the genus *Mesembrioxylon* Seward.[1] This admittedly artificial genus was founded to include woods previously

[1] Seward, A. C., Fossil plants, Vol. IV, *Cambridge*, p. 203, (1919).

described under *Podocarpoxylon* Gothan, *Phyllocladoxylon* Gothan and *Paraphyllocladoxylon* Holden. Our species shows a combination of characters which is not found in any other wood known to me. Its chief distinctive features are the faintly visible growth-rings combined with the very low medullary rays, the eiporen, the very numerous resin plates in the tracheids and the large stone cells in the pith.

Mesembrioxylon shanense, sp. nov.

Diagnosis. Growth-rings scarcely visible under the microscope; resin canals absent, but numerous resin plates or spools in the tracheids; wood parenchyma not seen. Pith parenchymatous with scattered stone cells, surrounded by numerous endarch primary bundles. Radial pits uniseriate, circular, separate, pore round or elliptic and oblique. Medullary rays uniseriate, very low, usually 1-2 cells high, cells laterally compressed, pits in the field one (rarely two) large, borderless (Eiporen).

Locality.—In the railway cutting half a mile east of Loi-an station, near Kalaw, Southern Shan States. Collected by Dr. L. A. N. Iyer, Geological Survey of India.

Horizon.— Loi-an Series.

G. S. I. Type No.—16358.

Comparisons.—In individual features our wood resembles several species, *e.g.*, *M. schwendæ* (Kub.) Sew.[1] from the Cretaceous or Tertiary of Austria; *M. gothani* (Stopes) Sew.[2] from the Aptian of England; *M. parthasarathyi* Sahni[3] from the Upper Gondwanas (Jurassic) of Southern India; *M. malerianum* Sahni[4] from beds in Rewah, Central India, which most probably also belong to the Upper Gondwanas[5] and *M. sewardi*, Sahni[6] from the Walloon series (Jurassic) of Queensland. In the first three and in the last named species the pith has been found preserved, and in all cases it contains sclerotic cells, but there are several points of difference. Thus in the Madras species the medullary rays are much higher and the

[1] Seward, A. C., Fossil Plants, Vol. IV, p. 209, (1919); Kubart, B. *Oest. Bot. Zeitschr.*, LXI (5), p. 161, (1911).

[2] Seward, A. C., *Loc. cit.*, p. 207, (1919); Stopes, M. C. *Brit. Mus. Catalogue*, p. 228, (1915).

[3] Sahni, B., *Pal. Ind.*, N. S., Vol. XI, Pt. II, p. 60, (1931).

[4] *Ibid.*, p. 63.

[5] *Ibid.*, p. 115.

[6] Sahni, B., *Queensland Geol. Surv.* Publication No. 267, p. 23, (1920).

field pits are not eiporen. *M. gothani* seems a little closer to our species, but the rays are somewhat higher, while the pits in the field are not so large and are oval in shape; moreover, the ordinary cells of the pith, apart from the stone cells, are rather thickwalled. In *M. schwendæ* the medullary rays are higher, and the field pits are usually bordered, with an obliquely vertical pore, though sometimes there is a single large eipore. *M. malerianum* resembles our plant in its very low medullary rays, but has several bordered pits in each field. Lastly, *M. sewardi* has in each field a single large circular eipore, resin spools in the tracheids and low medullary rays—features in which it approaches *M. shanense.* But the two species are very different in the structure of the pith, which in the Australian form consists entirely of thickwalled cells.

M. sewardi, moreover, has very sharply defined growth rings, even the spring and autumn wood within each ring being clearly marked off from one another.

III.—AFFINITIES.

In the first place we might enquire if this wood can have belonged to any of the conifers whose vegetative shoots have been described from the Loi-an series. A correlation of fossil woods with detached vegetative shoots must always remain a matter of uncertainty, because inevitably our genera have to be more or less artificial. The wood genus *Mesembrioxylon,* as Professor Sir A. C. Seward has clearly stated,[1]

> 'undoubtedly includes species which if additional data were available would be assigned to distinct genera'.

Although, thanks chiefly to the work of Professor Gothan, our knowledge of coniferous woods is now sufficiently advanced to make it highly probable that *Mesembrioxylon* is pre-eminently a genus of Podocarpinean conifers, we must not forget that this genus sometimes grades into *Cupressionxylon* in such a way as to make the distinction almost vanish. In dealing with these borderline species the only helpful criterion lies in the medullary ray pits of the spring wood,

> 'the pore being narrow and more or less vertical in *Mesembrioxylon* ("podocarpoid pitting" of Gothan), wider and more nearly horizontal in *Cupressionxylon* ("cupressoid pitting" of Gothan)'.[2]

[1] Seward, A. C., Fossil Plants, Vol. IV, p. 206, (1919).
[2] Sahni, B., *Pal. Ind.*, N. S., Vol. XI, Pt. II, p. 53, (1931).

This criterion can only be usefully employed in well preserved specimens in which the spring wood is available. Our specimen is neither well preserved nor has well marked growth-rings. But fortunately the critical character of the medullary ray pits is quite well seen : wherever the pits in the field are preserved at all they are clearly of the type of eiporen, that is, large, borderless pits, in which the question of the vertical or horizontal position of a slit does not arise. That section of *Mesembrioxylon* in which the field pits are of this type seems to belong to the Podocarpineæ rather than to the Cupressineæ. Sclerotic cells in the pith are also a well marked character of the Podocarpineæ. *Our specimen is therefore most probably the wood of a podocarp.*

As regards the vegetative shoots, two of the four species were referred to *Cupressinocladus* (*? Thuites*), one to *Pagiophyllum* and one to *Brachyphyllum*. The probable affinities of these shoots have already been discussed elsewhere.[1] Only the first-named genus can be assigned with any confidence to a known family, namely the Cupressineæ, and it seems out of the question that our wood should belong to that group. One or two species of the genus *Brachyphyllum* possibly belong to araucarian conifers but the affinities of the majority of species are quite unknown; some of them may well be Podocarpineæ. *Pagiophyllum* is an equally artificial group, among which members of more than one family are almost certainly represented : and it is not impossible, though of course we have no proof, that *Mesembrioxylon shanense* belonged to *Pagiophyllum burmense*. Without further data, however, these discussions are rather futile.

The upshot is that our fossil, the only petrified conifer yet known from Burma, is very probably the wood of a podocarp which may or may not have belonged to one of the species of vegetative shoots described from the same region. As we shall see presently, the question of the affinities of the plant is important from the geographical point of view.

IV.- PALAEOGEOGRAPHICAL CONSIDERATIONS.

It would be interesting to know whether the affinities of our fossil lie more with some species from the Far East, or with members of the Gondwana flora. Palæobotanical evidence clearly suggests

[1] Sahni, B., *Pal. Ind.*, N. S., Vol. XI, Pt. II, p. 105, (1931).

that during the early Mesozoic era Szechuan, Yunnan, and Tonkin formed parts of a botanical province rather distinct from Gondwana Land.[1] About the distinctness of these two provinces in the late Palæozoic there is no doubt whatever: this is shown by the great contrast between the *Glossopteris* flora of India and Australia and the *Gigantopteris* flora of China and regions further south. It was this palæobotanical contrast which first suggested that the two regions must have been originally separated by an ocean barrier;[2] and the belt of marine sediments in the meridional range of mountains in the Assam-Burma-Malaya region must obviously have formed the barrier in question. Towards the end of the Palæozoic and the early Mesozoic the barrier appears to have become less effective: the sharp contrasts of the earlier floras were not maintained. It is a significant fact that the mountain belt in Burma lies *west* of the Shan plateau, which therefore cannot have formed a part of Gondwana Land. Detailed work on the fossil floras of the Shan States should probably confirm this suspicion, already suggested in 1931[3] by the affinities of some of the conifer shoots from the Loi-an series. In fact all the available geological evidence, recently summarized by Wadia,[4] seems clearly to go in support of this view.

The above considerations suggest that this fossil wood from East Burma should be compared with any species of Mesozoic conifers that may be found in China and Japan or in other parts east of the meridional mountain belt of Burma-Malaya. I am not aware of any fossil woods of the *Mesembrioxylon* type yet described from the Far East, but our knowledge of petrifactions from that region is still very imperfect.

V.—GEOLOGICAL AGE.

As stated, the genus *Mesembrioxylon* was founded to include woods previously described under *Podocarpoxylon* Gothan, *Phyllocladoxylon* Gothan and *Paraphyllocladoxylon* Holden. These genera, taken together, range in geological age from the Jurassic to the Tertiary.[5] The new species therefore does not contradict a Jurassic age for the beds in which it was found.

[1] Sahni, B., *Journ. Ind. Bot. Soc.*, October 1936.
[2] Halle, T. G., *Palæont. Sinica*, Ser. A, 2(i), pp. 288-290, (1927).
[3] Sahni, B., *Pal. Ind.*, N. S., Vol. XI, Pt. II, pp. 116-117, (1931).
[4] Wadia, D. N., *Himalayan Journal*, Vol. VIII, pp. 63-68, (1936).
[5] Seward, A. C., Fossil Plants, Vol. IV, p. 173, (1919).

VI.—SUMMARY AND CONCLUSIONS.

This new species of *Mesembrioxylon* from the Loi-an series, probably the wood of one of the Podocarpineæ, is characterised by poorly marked growth-rings, very low medullary rays, large eiporen in the field, numerous resin plates in the tracheids and a thin-walled pith containing large scattered stone cells.

The only fossil conifers previously known from this area were a few vegetative shoots collected in the same series of strata.

The Podocarpineæ may be represented among these shoots but we cannot say this for certain, as some of the shoots belong to highly artificial genera (*Brachyphyllum*, *Pagiophyllum*). Whether the fossil wood belonged to the same species or genus of conifers as one of these shoots must therefore also remain an open question.

Although poorly preserved, the fossil is of interest as the first petrified conifer to be found in Burma, a region of considerable importance from the plant-geographical point of view. Previous work on the flora of the Loi-an series and of the adjoining regions of China and Indo-China has suggested that Eastern Burma during the Palæozoic and early Mesozoic had more affinity with the Far-Eastern botanical province than with Gondwana Land. The affinities of the new species are not clear but its geographical position suggests that it will probably turn out to be related to an oriental type rather than to one from the Gondwanas.

The genus *Mesembrioxylon* ranges in age from Jurassic to Recent. The occurrence of *M. shanense* in the Loi-an series does not contradict a Jurassic age suggested for these beds on other grounds.

My thanks are due to Mr. K. N. Kaul, M.Sc., for the photographs and camera-lucida sketches illustrating this paper.

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VIII.—EXPLANATION OF PLATE.

All the figures are untouched photographs. The type specimen and figured sections are preserved at the Geological Survey of India, Calcutta (Registered G. S. I. Type No. 16358).

Mesembrioxylon shanense, sp. nov.

PLATE 31, FIG. 1. Transverse section showing pith with stone cells, endarch protoxylem and wood devoid of growth-rings. (× 35).

FIG. 2. Tangential section showing low medullary rays and resin plates in tracheids. (× 200).

FIG. 3. Radial section through pith and early wood. (× 32).

FIG. 4. Radial section showing bordered pits and resin plates in tracheids. (× *ca.* 600).

FIG. 5. Radial section to show eiporen in medullary ray. (× *ca.* 500).

FIG. 6. Radial section to show structure of pith. (× 121).

SOME FORAMINIFERA FROM INTERTRAPPEAN BEDS NEAR RAJAHMUNDRY. By S. R. NARAYANA RAO., M.A., AND K. SRIPADA RAO, M.Sc., *Department of Geology, University of Mysore.* (With Plates 32 and 33.)

CONTENTS.

I.—INTRODUCTION.

The material used in the present report was collected from the following localities :—

Pangadi.—A village about eight miles to the west of Rajahmundry. The samples examined consist of :—

1. A blue calcareous marl, occurring as a tolerably persistent seam at the topmost horizon of the inter-trappean series in this region. The bed varies in thickness from a few inches to nearly a foot. It is crowded with marine shells and the finer siftings show calcite casts as well as the actual tests of foraminifera.
2. A compact, hard, fossiliferous limestone which attains a thickness of 12 ft. and probably more. This limestone is rich in foraminiferal and algal remains—the latter represented by three to four genera of the family *Dasycladaceae.*[1] In this compact limestone, the separation of the foraminifera from the matrix is almost impossible and many of the identifications had to be made from thin sections. However, on the weathered surfaces of these limestones, the tests of foraminifera may sometimes be seen protruding and their external characters made out.

[1] Two of these—*Neomeris* and *Acicularia*—are abundant at certain horizons and seem to have contributed materially to the formation of the limestones. A joint paper (J. Pia, S. R. N. Rao and K. S. Rao) describing the Rajahmundry micro-flora will appear elsewhere.

Kateru.—A village on the eastern bank of the Godavari about three miles north of Rajahmundry town. The sample examined consists of a green calcareous mud with abundant remains of *Chara* fruits. The finer washings show occasionally, well-preserved, though very much dwarfed, forms of foraminifera. Many of these forms are identical with those occurring in the Pungadi blue marl. It is evident that the Kateru Chara marl and associated limestones were deposited at the mouth of an estuary, which was in communication with the open sea in which the marine Pungadi limestones were formed.

The Rajahmundry beds must have been deposited during the great marine transgression which, in the words of Dr. C. S. Fox.[1]

'Appears to have attained its maximum extent about the time of the eruption of the basaltic lavas (the Deccan volcanic period) in the Peninsular region of India.'

The marine micro-fauna of Rajahmundry is therefore of more than usual interest and a detailed study may be of considerable help in establishing the stratigraphical relations of these beds with those of other areas of the southern marine province.

The present report has no pretensions to completeness and is intended to serve as a basis for future work. More data have still to be collected before any very satisfactory conclusions can be drawn regarding the age of the deposits or the depths at which they were formed. The fauna, so far identified, without being specially indicative, is not inconsistent with the following general conclusions.

(1) The sea in which the oceanic deposits of the Pungadi area were formed gave place, in its slow regression, to gulf and estuarine conditions. The Pungadi marl (the topmost horizon of the marine inter-trappean series) and the Kateru Chara marl were simultaneously deposited when the estuarine conditions were established. The abundant occurrence of typical pelagic forms like *Orbulina* and *Sphæroidinella* in the lower horizons of the Pungadi limestones, indicates that the physical geography during the Intertrappean period started with marine conditions of moderate depth. The deposits were probably formed very near the land, for there is a complete absence of siliceous remains like those of radiolaria. This, according to Brady[2], is inconsistent with the occurrence of deep oceanic deposits far from land.

[1] *Rec. Geol. Surv. Ind.*, LXIII, p. 187, (1930).
[2] Brady, H. B., *Quart. Journ. Geol. Soc.*, Vol. 48, p. 197, (1892).

Regarding the age of the beds, there are few restricted forms which can be definitely assigned to any horizon. It is however significant that typical Cretaceous forms like *Pseudotextularia*, *Gümbelina* and *Globigerina cretacea* are either very rare or altogether absent. On the other hand forms like *Orbitoidiae* and *Nummulites*, typical of the warm seas of the Eocene age, are also absent. According to data now available, the evidence of the foraminifera seems to be in favour of using the name Palæocene.

We desire to take this opportunity of recording our indebtedness to Mr. F. Chapman, A.L.S., F.R.M.S., Commonwealth Palæontologist of Australia, who kindly checked our identifications. Our thanks are also due to Prof. L. Rama Rao, M.A., F.G.S. Central College, Bangalore, for aid in the preparation of this paper and to the Director, Geological Survey of India, for his kindness in helping us with literature.

II.—DESCRIPTIONS.

FAMILY : *MILIOLIDAE.*[1]

Genus : SIGMOILINA, Schlumberger.

Sigmoilina, several species. Though several species are represented in thin sections of Pungadi limestone, sections satisfactory for a specific determination are not found. G. S. I. No. K 40/248.

Genus : TRILOCULINA, d'Orb.

Triloculina aff. *lævigata*, d'Orb.

(Plate 32, figs. 1 and 9.)

The exterior of the test is composed of but three chambers coiled end to end. Early chambers are quinqueloculine. Length from 0·5 mm. to 0·3 mm. Found in the Pungadi limestones. G. S. I. No. K 40/249.

Family : *LAGENIDAE.*

Genus : ROBULUS, Montfort. (CRISTELLARIA of many authors.)

[1] The classification and naming adopted is that followed by Cushman in his 'Foraminifera—their classification and economic uses, 1933.'

Robulus sp. *indet.*

(Text fig. 1.)

A dwarf form. Test nautiloid, compressed, with well developed keel. Rounded knobs along the periphery. Wall smooth, chambers numerous, costæ and umbonal region raised, aperture elongate.

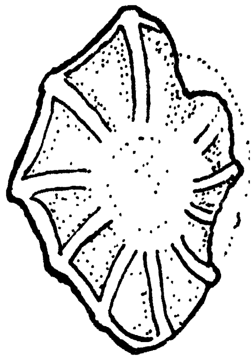

FIG. 1.—*Robulus* sp. *indet.*

Diameter 0·27 mm. *R. fomosus*, figured by Cushman,[1] most nearly resembles our specimen. *R. fomosus* differs in having peripheral spines instead of knobs and being much bigger in size. G. S. I. No. K 40/250.

Robulus cf. *occidentalis.*

(Plate 32, fig. 8, text-fig. 2.)

The keel is thin and transparent. The walls of the chambers are porcellanous. This agrees very closely with *R. occidentalis*,[2] described and figured by Cushman from Jamaica.

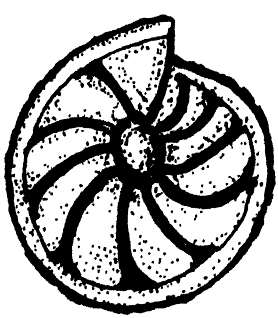

FIG. 2.—*Robulus* cf. *occidentalis.*

[1] Cushman, J. A. & Jarvis, P. W., *Jour. Pal.*, Vol. 4, p. 358, and Pl. 32, fig. 10, (1930).

[2] Cushman, J. A. & Jarvis, P. W., *Jour. Pal.*, Vol. 4, p. 357, (1930).

Both the above species show marked affinities with known Tertiary species. They are found very commonly in the Pungadi marl and Kateru Chara marl. G. S. I. No. K 40/251.

Genus: NODOSARIA.

Nodosaria zippei, Reuss.

(Plate 32, fig. 2.)

A single segment of this species was noticed in one of the sections from the Pungadi limestone. Wall calcareous, tuberculate. Diameter of a segment, 0·3 mm. This species is regarded by Chapman[1] as a restricted form found invariably in the upper Cretaceous. G. S. I. No. K 40/252.

Family: *NONIONIDAE.*

Genus: NONION, Montfort (Syn. NONIONINA, d'Orb.).

Nonion sp. *indet.*

(Plate 32, fig. 5.)

Test nautiloid, bilaterally symmetrical, with numerous chambers Wall perforate. Maximum diameter noticed 0·2 mm. This species appears to be identical with *Nonionina* sp., a Palaeocene foraminifera from the Samana Range, figured and described by Lt.-Col. Davies.[2] The Samana fossil is slightly uncoiled which, according to Cushman, is characteristic of the adult form of this genus. G. S. I. No. K 40/253.

Family: *HETEROHELICIDAE.*

Genus: GÜMBELINA, Egger. (TEXTULARIA of some authors).

Gümbelina globifera, Reuss.

(Plate 32, fig. 6.)

Test minute as is the case with this species; tapering, biserial, with round chambers. Length, 0·5 mm. There is a single specimen in our collection. G. S. I. No. K 40/254.

[1] Chapman, F., (1). *Annals of the South African Museum*, Vol. 12, pt. 4, p. 117.
[2] Davies, L. M., *Pal. Ind.*, N. S., Vol. XV, pt. 6, p. 77, Pl. 10, fig. 3, (1930).

Family : *GLOBIGERINIDAE.*

Genus : ORBULINA, d'Orb.

Orbulina cf. *O. universa*, d'Orb.

(Plate 32, fig. 7.)

The test is spherical, with the earlier chambers missing. Diameter of test, 0·3 mm. This specimen resembles *O. universa* described and figured by Galloway and Morrey.[1] Regarding this genus, Galloway[2] writes, " Test spherical in the adult, completely embracing a globigerinoid nucleoconch in the microspheric form which is missing in the megaspheric form, and possibly at other times by resorption ". *Orbulina* is a typical pelagic foraminifera and is restricted to Tertiary and later formations. This species is very common in the Pungadi region. G. S. I. No. K 40/255.

Genus : SPHEROIDINELLA, Cushman.

Spheroidinella sp.

(Plate 33, figs. 1 & 2.)

Test ovoid and inflated. Wall hyaline and coarsely perforate. Diameter of test, 0·6 mm. Diameter of pores, 0·02 mm. nearly. This also is a pelagic form quite frequent in the Pungadi limestones. G. S. I. No. K 40/256.

Family : *GLOBOROTALIDAE.*

Genus : GLOBOTRUNCANA, Cushman. (DISCORBINA and ROTALIA of some authors.)

Globotruncana sp.

(Plate 33, figs. 11 & 12.)

Chambers globose, and cancellated. Much eroded fragments of these were noticed and a specific determination is not possible. G. S. I. No. K 40/257.

[1] Galloway, J. J. & Margaret Morrey., *Jour. Pal.*, Vol. 5, No. 4, p. 349, Pl. 40, fig. 1, (1931).
[2] Galloway, J. J., A manual of Foraminifera, p. 333, (1933).

Genus: GLOBOROTALIA, Cushman.

Globorotalia cf. *G. menardii*, d'Orb.[1]

(Plate 32, fig. 4.)

Dorsal side of the test is strongly convex while the ventral side is slightly concave. Peripheral margin thin, wall calcareous and perforate. The tests are minute and more than one species is represented in the finer washings of the Pungadi and Kateru marls. G. S. I. No. K 40/258.

Family: *ANOMALINIDAE*.

Genus: *Anomalina*.

Anomalina rudio, Reuss.

(Plate 32, fig. 3.)

Test much compressed with numerous chambers. This is a shallow water species restricted to the higher levels of the Pungadi limestones. G. S. I. No. K 40/259.

III.—BIBLIOGRAPHY.

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[1] Cushman, J. A., *Geol. Surv. Florida*, Bull. No. 4, Pl. 12, fig. 1, (1930).

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FOX, C. S. (1930) . . *Rec. Geol. Surv. Ind.*, 63.

GALLOWAY, J. J., AND MARGARET MORREY, (1931). *Jour. Pal.*, Vol. 5, No. 4.

GALLOWAY, J. J. (1933) . A manual of Foraminifera.

JARVIS, P. W. (1930) . Miocene Foraminifera from Buff's Bay, Jamaica. *Jour. Pal.*, Vol. 4.

IV.—EXPLANATION OF PLATES.

PLATE 32, FIG. 1. *Triloculina* aff. *lævigata*. × 100. G. S. I. No. K 40/249.

FIG. 2. *Nodosaria zippei*, a single segment. × 100. G. S. I. No. K 40/252.

FIG. 3. *Anomalina rudio* Reuss. × 50. G. S. I. No. K 40/259.

FIG. 4. *Globorotalia* cf. *G. Menardii*, d'Orb. × 100. G. S. I. No. K 40/258.

FIG. 5. *Nonion* sp. ind. × 120. G. S. I. No. K 40/253.

FIG. 6. *Gümbelina globifera*, Reuss. × 150. G. S. I. No. K 40/254.

FIG. 7. *Orbulina* cf. *O. universa*. × 100. G. S. I. No. K 40/255.

FIG. 8. *Robulus* cf. *R. occidentalis*, by reflected light. × 80. G. S. I. No. K 40/251.

FIG. 9. *Triloculina* aff. *lævigata*, by reflected light. × 60. G. S. I. No. K 40/249.

PLATE 33, FIG. 1. A section of Pungadi limestone showing *Spheroidinella* sp., *Globotruncana* sp., and fragments of calcareous alga, *Acicularia*. × 80. G. S. I. No. K 40/256.

FIG. 2. A section of Pungadi limestone showing *Spheroidinella* sp., *Globotruncana* sp., and the calcareous algæ *Neomeris* and *Acicularia*. × 50. G. S. I. No. K 40/257.

Holosporella cf. *H. siamensis*, PIA, FROM THE RAJAHMUNDRY LIMESTONES. BY S. R. NARAYANA RAO, M. A., AND K. SRIPADA RAO, M. SC., *Department of Geology, University of Mysore.*

Holosporella, a name introduced by Dr. Julius Pia[1] for a new genus of calcareous alga of the family *Dasycladaceae*, hitherto known from a single locality, has recently been found in the limestones associated with the Rajahmundry volcanics (Deccan trap series) near Pungadi (17° 01′ : 81° 39′)—a village about 8 miles to the west of Rajahmundry town.

Holosporella siamensis, Pia., the original species on which the genus is founded, was figured and described by Dr. J. Pia in 1930, from the Kamawkala limestone (Upper Triassic) collected from the Burmo-Siamese frontier. He described the Siamese fossil as a " sporangial tube of a *Dasycladaceae* otherwise devoid of calcification." The sporangial cylinder in this genus, is, according to him, formed of sporangia situated in the axial cell of the alga and hence its description as an ' endospore ' *Dasycladaceae*. The presence of an axial perforation distinguishes this new genus from *Aciculella* and *Acicularia*, while the absence of the calcareous skeleton or casing distinguishes it from *Diplopora*. An ' endospore ' axial cell is considered to be a primitive character found more commonly in the Palæozoic and Mesozoic genera.

A noteworthy feature of the Triassic *Dasycladaceae* is their limited vertical range. Species appear to have changed with great rapidity. The unexpected find, therefore, of a Triassic species in beds as high as the Deccan volcanic period is of considerable interest.

The matrix in which the present specimen is imbedded is an extremely hard, compact limestone. Foraminifera and calcareous algæ, chiefly *Neomeris* and *Acicularia*, have contributed in no small measure to the formation of this limestone. *Holosporella* is very rare and even then represented by a few small fragments. We may

[1] *Rec. Geol. Surv. Ind.*, LXIII, pp. 177-181, (1930).

probably account for the rarity of this genus in a fossil condition to the absence of a protective casing of lime, which is well developed in some forms like *Neomeris* and *Diplopora*, enormously increasing their chance of preservation.

The following description is based on slide G. S. I. No. K 40/260.

Description.

Holosporella cf. *siamensis.*

Thallus cylindrical with a relatively broad axial tube. Wall fairly thick with a single row of spherical sporangia. The calcareous matter filling the cavity is crystalline, while the sporangial cavities are filled with a dark opaque matter probably carbonaceous in character.[1]

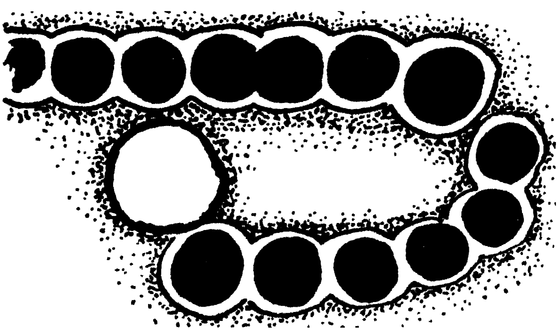

FIG. 1.—*Holosporella* cf. *siamensis.*

Measurements.

	Holosporella from Rajahmundry.	*Holosporella siamensis.*
Outer diameter of cylinder . . .	about 0·51mm.	about 0·4mm.
Diameter of central perforation . .	about 0·21mm.	about 0·15mm.
Diameter of globules	0·12—0·15mm.	about 0·21mm.
Thickness of membrane	about 0·01mm.	about 0·01mm.

[1] Pia, J., *Jour. Pal.*, Vol. 10, p. 6, (1936).

Remarks.—In its perforated thallus and the absence of the outer skeleton encasing the axial cell, the Rajahmundry fossil agrees with Dr. Pia's definition of the genus *Holosporella.* In general appearance and dimensions, it appears to be specifically identical with the Siamese fossil. Dr. Pia, who has examined our specimen, while confirming the identification, was kind enough to supply the following valuable and interesting notes :—

'I am not able to find out any essential difference between your fossil and my *H. siamensis* from the Upper Triassic of the Burmo-Siamese frontier. The measurements are well within the probable variability of one and the same species.

This occurrence is obviously most perplexing. A Triassic age of the Intertrappean beds is, of course, out of the question, not only for geological reasons, but also on account of the algal genera *Acicularia* and *Neomeris* found in them. On the other hand, the proofs given for the inclusion of the Kamawkala limestones from the Burmo-Siamese boundary with the Upper Triassic (Gregory, 1930, and the following papers in the same volume) seem to be convincing enough. It would, however, be against all our experience to suppose that a species of the *Dasycladaceæ* did survive from the Triassic into the Tertiary or even into the Upper Cretaceous time.

Two other explanations will have to be kept in mind. It may be that the geological structure of the limestones near the Thaungyin river is much more complex than we suppose. On the other hand the genus *Holosporella* does not yield as many clear characters for the definition of a species as *Dasycladaceae*, with a more complete calcification of the thallus, do. Similar sporangial cylinders may have been formed in the axial cells of algæ very different with respect to the structure of the branches. To make a choice between these two possibilities we have to await further discoveries. In any case the existence of an endospore *Dasycladaceae* in so high a geological horizon is quite unexpected a fact and probably a new instance of the survival of primitive forms in tropical regions.'

It may however be mentioned that this is not the first instance of such a record in India, as far as fossil algæ are concerned, for Dr. Walton[1] has described *Triploporella*, originally regarded as an extinct Cretaceous alga,[2] from the Ranikot beds (Lower Eocene) of Sind. G. S. I. No. K40/260.

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(1) Pia, J.,—A new *Dasycladaceae Holosporella siamensis*, nov. gen., nov. sp., with a description of the allied genus *Aciculella* Pia. *Rec Geol. Surv. Ind.*, 63, pp. 177-181, (1930).

[1] Walton, J., *Rec. Geol. Surv. Ind.*, LVI, pp. 213-219, (1924).
[2] Seward, A. C., Plant life through the ages, p. 423, (1933).

(2) Pia, J.,—Calcareous algæ from the Upper Cretaceous of Tripoli (North Africa). *Jour. Pal.*, Vol. 10, p. 6, (1936).

(3) Walton J.,—On a calcareous algae belonging to the *Triploporelleae* (*Dasycladaceae*) from the Tertiary of India. *Rec. Geol. Surv. Ind.*, 56. pp. 213-219, (1924).

(4) Seward A. C.,—Plant life through the ages, p. 423, (1933).

A NOTE ON THE MALERI BEDS OF HYDERABAD STATE (DECCAN) AND THE TIKI BEDS OF SOUTH REWA. BY N. K. N. AIYENGAR, M. A., *Field Collector, Geological Survey of India.* (With Plate 34.)

Among the Gondwana rocks of India, the three chief places where Triassic reptilian fossils occur are, (1) near Deoli in the Panchet rocks, Raniganj coalfield, (2) around Maleri in the Pranhita-Godavery valley, Hyderabad State, and (3) at Tiki in south Rewa.

The writer was deputed to collect reptilian fossils near Tiki in 1929-30 and 1935, and Maleri in 1935. As these localities were not easily accessible, few geologists have visited them in recent times.

(1) Deoli.

The presence of Triassic reptilian fossils has already been recorded in the Panchet beds of the Raniganj coalfield. They occur chiefly

'Just[1] North of the village of Deoli, near Bakúlia, and about quarter of a mile East of the mouth of the Besram stream, a considerable expanse of rocks is exposed in the bed of the Damúda, South of the channel occupied by the water in the dry season, and here a bone bed was found, containing detached, and, frequently, rolled bones, vertebræ, and fragments of jaws with teeth; they are not very abundant, but a considerable number were procured. Some were also found in another spot in the Damuda, a little East of the village of Dikha and fragments of bone were occasionally met with in other localities.'

The fossils from these beds have been described by Thomas Huxley[2] and W. T. Blanford[3]. The latest account of these Panchet beds is to be found in Mr. E. R. Gee's memoir on the Raniganj coalfield.[4]

(2) Maleri.

Maleri (Marweli of the map, sheet 56 M/12; 19° 11′ : 79° 36′) is a village ten miles E. N. E. of Rechni Road railway station on

[1] *Mem. Geol. Surv. Ind.*, III, Pt. 1, p. 129, (1861).
[2] *Quart. Journ. Geol. Soc.*, XVII, Pt. 1, p. 362, (1861). *Pal. Ind.*, Ser. IV, Vol. I, Pt. I, (1865).
[3] *Pal. Ind.*, Ser. IV, Vol. I, Pt. I, p. 25, (1865).
[4] *Mem. Geol. Surv. Ind.*, LXI, pp. 54-59, (1932).

the Kazipet-Balharshah section of H. E. H. the Nizam's State Railway in the Asafabad district of Hyderabad.

Though the earliest geological work in this area began as long ago as 1833, definite geological and palæontological work of interest was first commenced by the Rev. S. Hislop[1] in 1856. Later investigators were T. Oldham[2], W. T. Blanford[3], T. W. H. Hughes[4], R. Lydekker[5] and W. King[6].

The writer's work was chiefly confined to the central part of the Maleri formation around Maleri itself, though he traversed some parts in the southern area as well. The present description refers mainly to the country in the neighbourhood of Maleri.

Lithology.

The country near Maleri is slightly undulating, with a few shallow streams. The land is covered either with black cotton soil or Maleri red clays. In some places chipped rocks (Palæolithic flints) are found. As in the case of the Tiki formation, which will be described later, in the Maleri beds sandstones are subordinate to clays. A good and complete section of the rocks of the Maleri formation is not seen near Maleri itself, but after examination of some of the exposures south-west of Maleri and at the water gate of Rampur village (Pl. 34, fig. 1), the writer thinks that the following generalised section will give an idea of the probable stratigraphy of the formation near Maleri :—

	Feet.
Black cotton soil	2—4
Sandstone boulder bed	2
White or light grey, felspathic, occasionally calcareous, sandstone. (In some places this sandstone is considerably decomposed and mixed with much *kankar*)	4—7
Nodular, cherty looking, calcareous rock (seen south-west of Maleri)	5
Fine grained thinly laminated, grey calcareous sandstone, showing false bedding	5
Coarse rubbly calcareous sandstone. (This bed has yielded reptilian fossils in certain places)	2—3
Red clay,—thickness not known.	

[1] *Quart. Journ. Geol. Soc., London*, XVII, p. 348, 1861, XX, p. 280, (1864). *Journ. Bombay Br. R. A. S.*, Vol. VI, p. 202, (1861).
[2] *Mem. Geol. Surv. Ind.*, I, pp. 295-309, (1859).
[3] *Mem. Geol. Surv. Ind.*, IX, pp. 295-330, (1872), Pal. Ind. Ser., iv, Vol. 1, Pt. 2, pp. 17-23, (1878).
[4] *Rec. Geol. Surv. Ind.*, IX, p. 86, (1876).
[5] *Pal. Ind. Ser.*, IV, Vol. I, Pt. 5, (1885).
[6] *Mem. Geol. Surv. Ind.*, XVIII, Pt. 3, pp. 118-123, (1881).

Owing to their softness, the red clays do not show any bedding, but the rubbly sandstone bed immediately overlying them shows a dip of 10°-12° in a north-east or N. N. E. direction.

Though the Maleri formation extends from Sandgaom (19° 35′ : 79° 42′) to Semnapali (18° 42′ : 79° 54′), a distance of about 60 miles, reptilian fossils have been found only in the central part of this area, that is, between Maleri and Nannial (19° 4′ : 79° 38′), and in the Angrezapalli (18° 48′ : 79° 47′) outlier. The reason for this appears to be that the beds containing fossils have been well exposed in these places owing to the gentle dip, which has allowed rapid weathering of the rocks, and has also prevented the fossils so exposed from being washed away by rains. Such is the country bounded by the villages, Teklapalli (19° 8′ : 79° 35′), Nannial (19° 4′ : 79° 38′), Kanepalli (19° 9′ : 79° 40′), Venkatapur (19° 11′ : 79° 38′), Bhimni (19° 12′ : 79° 38′) and Achlapur (19° 10′ : 79° 32′).

Fossil collection.

Owing to the flatness of the country and constant cultivation, fossils are sparsely distributed. One of the best methods adopted by previous workers like Hislop and Hughes for collecting fossils in this area which met with much success, was by "beating" (Pl. 34, fig. 2). In making further collections, the same method was followed by the writer, whose provisional identifications of the fossil collections from Maleri are as follows :—

(1) One mile north-east of Maleri in the stream exposures.

Hyperodapedon huxleyi, Lyd.—Maxilla, dentary bones and scutes.

Parasuchus sp.—Teeth, vertebræ and imperfect limb bones.

Belodon sp.—Limb bones.

Unio sp.—

(2) Half a mile north of Maleri in the black soil.

Hyperodapedon sp.—Vertebræ and bones.

Labyrinthodont.—Dentary bones.

Unio sp.—

(3) One mile north-west of Maleri in the red clay.

Hyperodapedon sp.—Maxillæ.

Unio sp.—

(4) One mile south-west of Maleri.

Large limb bones, vertebræ, scutes, maxillary and dentary fragments, probably belonging to *Belodon*. All these specimens

were collected at one spot, and they may belong to the same individual.

(5) About five furlongs north of the last mentioned locality, were found two large ? Dinosaurian vertebræ and two or three species of the fish *Ceratodus*. In addition to these fossils, coprolites are abundant about half a mile W. S. W. of Maleri. They are generally greenish yellow in colour varying in size from that of a walnut to a cocoanut. In shape some are flat and cake-like, some cylindrical, spiral, reniform or botryoidal. In cross section they present a central core surrounded by layers of iron-impregnated material. The nature of the material of these coprolites collected has not yet been examined.

(6) One mile E. S. E. of Achlapur.

Hyperodapedon sp.—Bones, imperfect maxillæ.

Unio sp.—

(7) Half a mile north of Rechni village.

Remains of *Hyperodapedon* sp. and *Unio* sp.; the latter are much smaller in size than those found at Maleri.

(3) Tiki.

Tiki (81° 22′ : 23° 56′) sheet 64 E/5, is a small village about seven miles south of Beohari, and about fifty miles north-east of the Umaria coalfield in south Rewa. The best route to this locality is *viâ* Sutna and Rewa.

Previous observers.

Reptilian fossils were first noticed near Tiki by T. W. H. Hughes about the year 1879, during the course of his survey of the south Rewa Gondwana basin[1]. The collection made by him in this area has been described by Lydekker[2]. Dr. G. de P. Cotter,[3] who visited this place during the year 1916 to investigate the relationship of the Tiki beds with the Parsora formation, also collected some reptilian remains near Tiki.

Topography.

Like most Gondwana areas, the country around Tiki is slightly undulating. The softer red clays and sandstones have been much denuded. Wherever harder rocks like the ferruginous sandstones of the upper division

[1] *Rec. Geol. Surv. Ind.*, XIV, Pt. 1, p. 136, (1881).
[2] *Pal. Ind.*, Ser. IV, Vol. I, Pt. 5, (1885).
[3] *Rec. Geol. Surv. Ind.*, XLVIII, Pt. 1, p. 27, (1917).

protect the clays below, they give rise to flat-topped hills, like the Hartala and Beohari hills.

Lithology.

As already mentioned the rocks can be divided into two distinct lithological divisions. The upper division is chiefly composed of hard ferruginous sandstones with rounded pebbles at the top. These beds overlie fine-grained grey hard sandstones with red laminations, and some purple shales. Some good varieties of such rocks are quarried near Beohari for building purposes. So far no fossils, either plant or animal, which would help in determining their age, have been found in these rocks. They may represent the upper division of the Tiki beds or may be younger than the latter. The lower division, known as the Tiki stage, in which reptilian fossils, fossil wood, and fresh-water shells like *Unio* occur, is made up mostly of red and green clays with subordinate sandstones. These sandstones are often calcareous. Fine green laminations and green clay galls are very characteristic of these sandstones, and in some places the calcareous matter segregates on the surface of the sandstones near Tiki and forms a thick vermicular encrustation on them. False bedding is very common, and calcified or carbonised fossil wood is sometimes found. The red clays, being softer and more easily denuded, form the lower ground. They are full of yellow *kankar*. The red clays make their first appearance in the Son River section a mile up the stream from Giar. The following section, which is seen on the right bank of the Son at Giar (23° 30′ : 81° 19′), may be taken as a type one for the Tiki beds :—

	Feet.
Siliceous sandstones, grey and brown in colour with decomposed folspars and clay galls	15
Fine-grained grey sandstones with interrupted green laminations, false-bedded, and containing partly carbonised and calcified fossil wood	5
Weathered calcareous rubbly grey sandstone	2
Fine-grained sandstone	2
Bright red clays,—thickness not known.	

This section has also been noticed by Hughes.

Though the red clays are found to cover a considerable area, fossils have been found only in those south of Tiki. In this locality reptilian and molluscan fossils are found on the much denuded clays. Most of the fossils are covered with calcareous matter and are much worn. Not a single fossil was seen *in situ*. It is not

definitely known from which beds these fossils are derived, but some fragments of fossils were enclosed in a rubbly calcareous matrix which occurs above the red clays. The writer, however, noticed in the Godavery area that fossils were present in such calcareous sandstones. The following fossils were found in the collection made near Tiki :—

Huperodapedon huxleyi, Lyd.—Fragmentary palato-maxillæ, dentary bones, vertebræ, etc.

?*Dinosaurian*.—Tooth.

Belodon sp.—Fragmentary maxilla, vertebra and teeth.

Parasuchus sp.—Limb bones, scutes and teeth.

An interesting frontal part of the internal cast of a saurian skull was also collected.

Unio sp.—

(Fish teeth, which are fairly common in the Maleri area, have not been found at Tiki.)

EXPLANATION OF PLATE.

PLATE 34, FIG. 1.—Exposure of Maleri beds at Rampur near Maleri.
FIG. 2.—Searching for reptilian fossils at Maleri, Hyderabad State.

THE STRUCTURE OF THE HIMALAYA IN GARHWAL. BY J. B. AUDEN, M. A., F. G. S., *Geologist, Geological Survey of India.* (With Plates 35 to 37.)

CONTENTS.

I.—INTRODUCTION.

The object of this paper is to summarise my present views on the structure of the outer Himalaya between the Jumna River and Lansdowne, as well as to introduce a preliminary interpretation of a profile across the Garhwal Himalaya from the Plains to the Main Himalayan Range. I shall not discuss lithology, or the stratigraphical relationships of the various rock groups. That will be reserved for a Memoir which it is hoped to write shortly.

At intervals during the last eight years it has been my duty to make a detailed survey of the lower Himalaya, working south-eastwards from Lat. 31°N. : Long. 77°E. to Lat. 30°N. : Long.

78° 30′ E. The region with which this paper is chiefly concerned lies east of Long. 78°E. and is about 1,500 square miles in area. In addition traverses have been made to the snowy ranges up the Alaknanda and Bhagirathi branches of the Ganges river. The whole region is included within Survey of India map No. 53, on the scale of 1 : 1,000,000; see Plate 36.

I. Historical.

In 1864 H. B. Medlicott published the first connected account of the geology of the lower Himalaya[1]. The area he described is about 7,000 sq. miles and lies for the most part west of the Tons river, centering around Simla. Important though this memoir is, it has little direct bearing on the region east of Long. 78°. Moreover, Medlicott's work has already been discussed by G. E. Pilgrim and W. D. West[2] and later to some extent by myself[3], so that it can be omitted from the discussion which follows.

Between 1885 and 1890 C. S. Middlemiss carried out detailed surveys in three areas of the Kumaon Division :—

(1) along the outer Himalaya between the Ganges river and Gungti hill (29° 45′ : 78° 55′)[4];

(2) around Dudatoli mountain (30° 03′ : 79° 12′)[5];

(3) the Siwalik ranges from the Ganges to the Nepalese frontier[6].

It is with the first area that we are most directly concerned, since it overlaps that in which I have worked and since it afforded indications of enormous tectonic movements in the Himalaya.

In 1891 C. L. Griesbach published a Memoir on his survey within, and north of, the Main Himalayan Range[7].

Between 1883 and 1888 R. D. Oldham published accounts of his mapping in the Chakrata Tahsil of Dehra Dun district and in regions to the west of the Tons river[8]. He was unfortunate in working on an isolated area of exceptional geological complexity,

[1] *Mem. Geol. Surv. Ind.*, III, (1864).
[2] *Op. cit.*, LIII, (1928).
[3] *Rec. Geol. Surv. Ind.*, LXVII, p. 357, (1934).
[4] *Rec. Geol. Surv. Ind.*, XX, p. 33, (1887).
[5] *Op. cit.*, p. 134, (1887).
[6] *Mem. Geol. Surv. Ind.*, XXIV, (1890).
[7] *Op. cit.*, XXIII, (1891).
[8] *Rec. Geol. Surv. Ind.*, XVI, p. 193, (1883); XXI, p. 130, (1888).

the southern part of which even now, after a fuller survey of the surrounding regions, has not yielded any satisfactory solution of structure.

After an interval of forty years, detailed mapping was begun in the Simla area by Pilgrim and West, who demonstrated for the first time in that part of the Himalaya the existence of great overthrusts[1]. I was attached to the Himalayan party in 1928, and, working to the south-east from Subathu, have joined up with the area already mapped by Middlemiss south-east of the Ganges river. A paper of mine on the Geology of the Krol Belt was published in 1934 in which the portion of the outer Himalaya between longitudes 77° and 78° was described[2]. A further paper was published in 1935 describing traverses carried out in the Karakoram, Garhwal, eastern Nepal and Sikkim[3].

2. Topographical and Geological Zones in the Garhwal Himalaya.

Before describing the tectonics of the Garhwal Himalaya in greater detail, a brief mention may be made of the zones into which it can be divided. Topographically the following zones may be distinguished :—

1. Siwalik Range and Dun.

2(*a*). Outer lower Himalaya, with an intricate network of spurs and rivers.

(*b*). Inner lower Himalaya, with simpler topography.

3. Main Himalayan Range, with steep scarp slopes facing towards the Plains, and gentler dip slopes facing Tibet.

4. High peaks north of the Main Himalayan Range with irregular disposition.

The structural units do not fit into this topographical classification, since, in some parts at least, three structural units are superimposed one upon the other. The main tectonic divisions for the Garhwal Himalaya are as follows :—

(1) Autochthonous unit. The base of this unit is probably the Simla slate series, overlying which occur Nummulitics,

[1] *Mem. Geol. Surv. Ind.*, LIII, (1928).
[2] *Rec. Geol. Surv. Ind.*, LXVII, p. 357, (1934).
[3] *Op. cit.*, LXIX, p. 123, (1935).

Murrees and Siwaliks. Thrusts occur within this unit, but do not seem to be of premier magnitude. The most important thrust is that which has long been called the Main Boundary Fault. This Autochthonous unit appears to occur well within the Himalaya, some twenty miles at least from the Dun.

(2) The Krol Nappe, thrust upon the Autochthonous unit, and corresponding to the Krol Belt described in a previous paper of mine.

(3) The Garhwal Nappes, thrust upon the Krol Nappe. The main Garhwal Nappe may root in the Main Himalayan Range.

(4) The Main Himalayan Range, which appears to be made up partly of elements common to one of the Garhwal Nappes and partly of a distinct group of para-gneisses and schists.

(5) The granite zone to the north of the Main Himalayan Range, containing granites intrusive into the southern para-gneisses and schists.

(6) The Tethys zone of fossiliferous sediments. The relationship of this zone to the granites and para-gneisses is at present obscure. From the work of Hayden in Spiti it would appear that the gneissic granite, which may be Permian or Tertiary in age, has an intrusive contact with the Cambrian. The recent work of Professor Arnold Heim and Dr. Gansser may clear up this question.

The greater part of this paper will be devoted to a discussion of the Autochthonous, Krol and Garhwal units occurring in the outer lower Himalaya. Before examining the results of recent work, it is necessary to summarise the interpretation given by Middlemiss to the outer lower Himalaya south-east of the Ganges river.

II.—MIDDLEMISS, 1887.

In 1887 Middlemiss published his important paper on the Physical Geology of West British Garhwal[1]. This was followed

[1] *Rec. Geol. Surv. Ind.*, XX, p. 33, (1887).

by a memoir on the Siwalik rocks in 1890[1]. The earlier work appears to have been carried out within two seasons, and one is amazed at the extent of ground covered and the general accuracy of the mapping. The only complaint is that, in a region offering so many problems, Middlemiss should intentionally have omitted elucidation of all except the most pressing one. The succession as determined by him is given below:—

——	Sub-Himalayan (Siwalik).
Outer Formation . .	Nummulitic. Tal. Massive Limestone. Purple Slates. Volcanic Breccia.
Inner Formation . . .	Schistose series with intrusive gneissic granite.

Middlemiss found that the schistose series occurred in an outcrop enclosed by, and apparently overlying, rocks of the Outer Formation. Almost all his discussion is confined to this relationship. His argument is summarised below.

The sequence of the rocks of the Outer Formation is a normal one, and is established by the presence in it of two fossiliferous horizons, Nummulitic and Tal limestone, the Nummulitic being the youngest and on top. The disposition of the Inner Schistose series in relation to this normally lying Outer Formation is best given in his own words[2]:—

'....at every point round the schistose area the Outer formations appear to dip towards and under the schistose series at steep angles (50°-60° generally); whilst the schistose series itself is disposed apparently in the form of an elongated quaquaversal synclinal upon the top of the Outer formations, and culminates in a capping of gneissose rock on the summit of Kalogarhi mountain.....

In other words, the observer after a hasty examination is almost driven to the conclusion that there is an upper metamorphic series lying normally upon the comparatively unmetamorphosed zone of Outer formations (a counterpart of the opinion long held with regard to the strata of the Scotch Highlands)'.

Again, on page 36, after commenting on the rocks of the Outer Formation being in their natural order (which is not true over

[1] *Mem. Geol. Surv. Ind.*, XXIV, (1890).
[2] *Rec. Geol. Surv. Ind.*, XX, p. 34, (1887).

part of the area) and dipping inwards towards the schistose rocks, he remarks :—

'One seems almost driven to conclude that if a boring were sunk through the centre of the schistose area, we should inevitably strike the Tal beds below'.

Middlemiss then attempts to prove that this conclusion would be wrong, claiming that the facts

'not only render the above interpretation unacceptable, but emphatically negative it'.

Firstly, he states on page 37 that if the Tal beds in reality continue below the schistose series, it follows that the Nummulitics, where present, must do the same :—

'that is to say, a soft, shaly, tertiary rock, not only must lie as a foundation on which the schists are piled, but also must be beneath them in direct contact'.

Such a case of selective metamorphism is ruled out as impossible, from which Middlemiss concluded that the schistose series must be older than the Nummulitics.

Secondly, having established that the schistose rocks are older than the Nummulitics, he argues that they must have been moved by reversed faulting against the Nummulitics. The argument on page 38 is a little involved, but the conclusion is that a combination of the 'sigma-flexure' with a reversed thrust plane is sufficient to explain the relative positions of the Outer and Inner Formations.

This same argument is repeated in *Memoirs, Geological Survey of India*, 24, pp. 73-77, (1890), namely that the Nummulitics must be younger than the schistose series, and that the rocks of the Outer Formation are separated from the overlying schistose series by a reversed fault. On page 74 of this memoir the fault is stated to dip in one place at about 25° northwards, as is also shown in Section VI.

It is necessary, therefore, on this thesis, to imagine a reversed fault, of ring shape, everywhere dipping inwards centripetally below the schistose series.

The argument of Middlemiss is weak, because it does not succeed in proving, as he imagined, that the schistose series cannot completely overlie the Nummulitics and Tals. It only indicates that the schistose series are older than the Nummulitics and that their

position with respect to the Nummulitics cannot be a normal stratigraphical one. It suggests nothing about the nature of the dislocation which has caused the Nummulitics and schistose series to be brought together by an abnormal contact. Middlemiss chose to assume a ring-shaped reversed fault and therefore an essentially autochthonous disposition, but did not consider the possibility of a great overthrust bringing the schists and slates to overlie completely the Nummulitics and Tals. He refers to the Scottish Highlands (pp. 33, 34), and specifically mentions the solution to the problem there by Peach and Horne, but considered that the Garhwal area examined on its own merits did not warrant a similar explanation. I hope to show later that the evidence does in fact point to the conception of a great overthrust.

The problem remained as Middlemiss left it for exactly fifty years. His map has been reproduced in both editions of 'A Sketch of the Geography and Geology of the Himalaya Mountains and Tibet' and in Wadia's 'Geology of India', but no attempt has been made in these publications to discuss the difficulties of structure implied by accepting the interpretation which Middlemiss adopted. His account was, however, read independently by Mr. West and myself, both of us feeling the excitement of the possibility of nappe structures latent in it.

III.—RECENT SURVEY, 1935-36.

During the last three seasons I have mapped east of Longitude 78°E. and have joined up the succession which I had established around Solon (described in 1934) with that of Middlemiss. Before reaching the Ganges river, I found both in 1935 and in 1936 structures in Tehri Garhwal which seemed to me to settle the validity of Middlemiss' condemned impression. Now, having examined part of the Garhwal area, some of it in detail, I am convinced of the existence of great overthrusts. There are, it is true, many difficulties involved in a region almost devoid of fossiliferous rocks, except the Tal limestone, (the fossils in which are so broken that no certain age has been assigned to them) and the Nummulitics, and in which there appear to be recurrences of rock types throughout the assumed stratigraphical succession. Yet some of the features seem clear and worth recording apart from those that are less explicable.

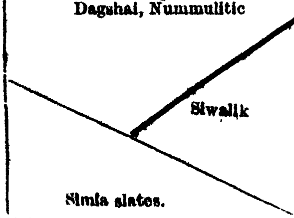
The following tables give the stratigraphical and tectonic successions which I have determined east of Longitude 78°. To the second table has been added the succession found by Middlemiss in Garhwal in 1887 :—

Succession east of Longitude 78° E.

Formations.	Unconformities.	Approximate Maximum Thickness.	Probable age.
Siwalik	..	16,000	Upper Miocene to Pleistocene.
	?		
Murree (almost absent east of Long. 78°) .	..	?	Lower Miocene.
	?		
Nummulitic	..	?	Eocene.
	~~		
Tal limestone and Calc grit	..	200	Upper Cretaceous ?
	~~		
Tal . { Upper Tal quartzites . . .	..	4,500	Cretaceous } ?
Lower Tal shales	..	2,000	Jurassic
	~~		
Krol . { Upper Krol dolomites, limestones and shales.	..	3,000	Trias } ?
Krol red shales	..	} 1,000	Permian
Lower Krol limestones and shales	..		
Blaini . { Infra Krol slates	..	} 2,000	? Talchir (Uralian).
Upper Blaini boulder bed and dolomite.	..		
	~~		
Blaini slates	..		
Lower Blaini boulder bed . .	..		
	~~		
Nagthat	..	3,000	Devonian ?
	~~		
Chandpur	..	4,000?	Lower Palæozoic and pre-Cambrian?
Simla slates, possibly equivalent to the Chandpur series, although different in lithology.	..	..	
Dolerites	..	..	Late Tertiary.

—— = Conformity.
~~~ = Unconformity.
~~~

Tectonic Succession in Tehri Garhwal and British Garhwal.

——	Tehri Garhwal and British Garhwal.	British Garhwal, Middlemiss, 1887.
Garhwal Nappes .	Chandpur (metamorphosed). ——thrust—— Nagthat } (little metamorphos- Chandpur } ed). Boulder beds, slates and limestones of uncertain stratigraphical horizon occur in one outlier below metamorphosed Chandpurs.	Inner Schistose series.
——*Garhwal Thrust*——		——*reversed fault*——
Krol Nappe . .	Nummulitic . . . . . Tal . . . . Krol. . . . . . . Blaini . . . . . . Nagthat } metamorphosed and Chandpur } unmetamorphosed.	Nummulitic. Tal. Massive Limestone. Volcanic Breccia in an undifferentiated group of Purple Slates
——*Krol Thrust*——		
Autochthonous . . .	 Dagshai, Nummulitic Siwalik Simla slates.	

I. Autochthonous.

1. SIWALIKS.

The structure of the Siwaliks east of the Ganges has already been described by Middlemiss, whose illustrative sections are classics in Indian geological literature. Between the Jumna and Ganges rivers the main structure is an anticline in the Siwalik Range (the axis of which is slightly oblique to the topographical alignment of the range), a syncline forming the Dun valley, and to the north-east an overturned anticline which is truncated on the north side by the Main Boundary Fault and the Krol Thrust. The base of the Siwaliks is nowhere seen, but it is presumed that it

consists of Nummulitics with attenuated Dagshai rocks resting on Simla slates; Section 1, Plate 37.

2. Dagshai and Nummulitics.

The Main Boundary Fault, in the sense originally used by Medlicott, separates the Siwaliks from the older Tertiaries which have been thrust upon them. East of Long. 78° the Dagshai rocks (Murrees) are very seldom seen, and the chief fault is the Krol thrust which has brought pre-Tertiaries forward so as to rest directly on Siwaliks. This Krol Thrust has been called the Main Boundary Fault both by Middlemiss and myself, but, although it does in fact form the northern boundary of the Siwaliks over some of the area between Dehra and Naini Tal, it is not the same fault as that to which Medlicott originally assigned the term[1].

In the neighbourhood of Solon and Subathu, Dagshai and Subathu rocks (Murree and Nummulitic) rest upon Simla slates and have been overthrust by the rocks of the Krol Nappe. This is well seen around the north-west end of Pachmunda Hill and along the Blaini river[2].

Dagshai rocks are seen along the Tons river by Kalawar (30° 32′ : 77° 49′), on the left bank of the Amlawa river at Kalsi, and as a very narrow outcrop running in a south-east direction to about Long. 78° 02½′. They are thrust by a steep reversed fault (Main Boundary) upon Nahan rocks and are themselves overthrust at a gentler angle by pre-Tertiaries (Krol Thrust). Lenticles of fossiliferous limestone in the Dagshai rocks of the Tons river suggest that Nummulitics may be present there as well.

Between Dehra and Rikhikesh, Nummulitics together with cindery nodular sandstones, which are probably Dagshai, rest upon Simla slates and have been overthrust by the rocks of the Krol Nappe. They occur in two windows which will be described in greater detail in the next section. Probable Tal rocks occur, though poorly exposed, in the Chandna Rao at 30° 10′ : 78° 15′ evidently to the south-west of the Krol Thrust and belonging to the same tectonic horizon as the complex Nummulitic and Tal association of Banas Talla and Banas Malla (29° 57′ : 78° 21′).

[1] Middlemiss, C. S., *Mem. Geol. Surv. Ind.*, XXIV, pp. 19, 31, (1890); *Mem. Geol. Surv. Ind.*, XXXVIII, p. 337, (1908).
Auden, J. B., *Rec. Geol. Surv. Ind.*, LXVII, p. 431, (1934).

[2] *Rec. Geol. Surv. Ind.*, LXVII, p. 436, (1934).

Within the Himalaya, Nummulitics are seen resting upon Simla slates at Sayasu (30° 42′ : 77° 44′), and from just north of Dabra (30° 40′ : 77° 49′) down to the Tons river. In the Tons river Dagshai rocks are almost certainly present in addition to the Nummulitics.

Numerous faults and thrusts occur in the rocks of this zone. It is possible also that the Tertiaries may have been pushed bodily over the Simla slate foundation, with the Nummulitics acting as a lubricating horizon, in a manner comparable to the anhydrite horizon at the base of the Mesozoic succession of the Jura Mountains. These movements are probably, however, of less magnitude than those involved in the Krol and Garhwal Nappes, and the term 'autochthonous' seems to be justified.

2. Krol Nappe.

The maximum thickness of the succession in the Krol Nappe is of the order of 20,000 feet (6,100 meters). This succession is a normal one, for the disposition of numerous exposures of current bedding in the calc grit of the Tal limestone, and in the Tal and Nagthat quartzites, shows that these particular stages are not inverted, and therefore that the whole succession is in the correct order. This is important because it eliminates the possibility of repetition of certain facies by recumbent folding. Thus, the Tal and Nagthat quartzites cannot be regarded as belonging to a single horizon which has been duplicated by recumbent folding around a core of Upper Krol limestone. This conclusion is also supported by the fact that the sequence of stages above the Upper Krol limestone, on the assumption that this is the core of a recumbent fold, is not the mirror-image reverse of that below the limestone. In particular, there is no equivalent of the Blaini boulder beds in a position between the Lower Tal shales and the Upper Tal quartzites, which would be expected if the Tal and Nagthat quartzites were the same horizon duplicated in a flat overfold. Moreover, there are lithological differences between the Tal and Nagthat quartzites which, though not absolute when regarded singly, are collectively valid enough to differentiate these two stages. This point has been stressed because Middlemiss evidently confused these two quartzites. At the beginning of his survey he considered the Tals to underlie the Massive (Krol)

Lack of inversion.

limestone, but he was later compelled to reverse their position and to place them above the limestone. He appears also in places to have mapped the true Tal quartzites and the Nagthat quartzites that have been overthrust upon the Tals, both as Tal.

It may be accepted therefore that the sequence given for the Krol Nappe is uninverted and has not been duplicated by recumbent folding. Nor do I think it possible to assume the duplication by thrusting of uninverted stages one upon another.

The evidence for the existence of this nappe is based upon the following considerations :—

(1) The most convincing evidence is the occurrence of two windows disclosing Nummulitics and Simla slates between Dehra and Rikhikesh. One of these windows occurs on both sides of the Bidhalna Rao (30° 16′ : 78° 14′) and is about six square miles in area. The other window is well seen between Pharat (30° 13′ : 78° 18′) and Banali (30° 11′ : 78° 20′) and covers about seven square miles[1]. They occur along the anticlinal axis which separates the Mussoorie syncline of Nagthat-Blaini-Krol-Tal rocks from the Garhwal syncline lying to the south of and *en echelon* with it. In the centres of the windows occur Simla slates, generally with steep dips. Above the Simla slates, sometimes as isolated cappings, more typically as a border to the windows, are found Nummulitic shales and limestones together with blocks of highly shattered quartzites, the surfaces of which are glazed by friction. Finally, above the Nummulitic and associated rocks occurs the unmetamorphosed facies of the Chandpur beds, belonging to the Krol Nappe. There can be little question here of the Nummulitics occurring as outliers in pockets of a late Cretaceous erosion topography. Such a manner of occurrence would not account for the difference in type of the slates found above and below the Nummulitics. While it is admittedly difficult in some places to distinguish the Simla slates from the Chandpur series (which are possibly of the same age but deposited in two distinct areas), the difference between these two series is on the whole marked enough in this particular region, so that the occurrence of the Nummulitics between the Simla slates and the Chandpurs is significant. The upward succession in these windows, Simla slates—Nummulitics—Chandpurs, is the characteristic

[1] This Banali should not be confused with another village of the same name situated at 30° 18′ : 78° 17′ 30″. The latter village is located on an outlier of the Garhwal Nappes (page 422).

feature, the disposition of the Nummulitics being such as to suggest that they are part of a continuous sequence, a sequence which I conclude to be tectonic. The strong shattering of the quartzites associated with the Nummulitics, their slip-polished surfaces, and their haphazard tectonic isolation as blocks in the shales, with no signs of orderly sedimentation, suggest that these rocks have been subjected to violent stresses. Indeed, below Banali the Nummulitic shales are converted into a 'pseudo-schist', resembling biotite-schist, but in reality a highly sheared shale endowed with abundant reflecting slip surfaces. These effects must have arisen during the Miocene movements, which are known to have been a characteristic feature of Himalayan tectonics, and are indicative of shearing stress rather than simple hydrostatic pressure. On the hypothesis that the Nummulitics rest upon a pre-Tertiary erosion topography, it would, however, be necessary to assume that this topography had undergone little change throughout the Tertiary and Quarternary eras. This would hardly be expected in view both of the extent of the Miocene movements, and of the great erosion which has taken place since then. If Miocene compression had shortened the width of the postulated valleys in which the Nummulitics had been deposited, so as to cause the infolding of the Nummulitics within the Chandpur and Simla slate series, it should have had a devastating effect on the pre-Tertiary north-south ridge separating these valleys. Yet the Chandpur beds of the narrow Diuli (30° 13′ : 78° 17′) ridge are neither shattered nor highly folded. The shattering occurs in the Nummulitic rocks which dip under the Chandpurs on either side of the ridge. In the view here adopted, the Nummulitics were deposited upon a more or less peneplaned surface of Simla slates, and were later overthrust by the Chandpur series of the Krol Nappe. The valleys in which the inferred windows are now exposed are regarded as the result of recent river erosion. Young river-gravels occur 800 feet above the level of these modern valleys.

(2) Between Solon and Subathu there is a similar disposition to that just described, except that the Chandpur and Nagthat beds of the Krol Nappe are missing. Here the sequence working upwards is :—Simla slates—Subathu (Nummulitic)—Blaini. This area has already been described, being figured on page 436, and discussed on pages 434-437 of *Records, Geological Survey of India*, 67, (1934). Near Solon there are two outcrops of Nummulitics, surrounded by Infra-Krol (Blaini *sensu lato*) slates, which I regard

as windows. The contacts between the Nummulitics and adjacent Blaini rocks are poorly exposed, and it might be maintained that the Nummulitics of these outcrops occur as eroded outliers upon Blaini. Nummulitics are known to lie infolded within Krol limestones at Bagar (30° 45′ : 77° 17′) evidently having overlapped the Tal rocks towards the north-west so as to rest directly upon the Krols, and it might be argued that this overlap continues in the direction of Solon across the Krol limestones on to the Infra-Krol (Blaini). The Krol limestones are, however, very well exposed near Solon, the type locality, so that this overlap could only be very local. Moreover, the same arguments apply to the Solon area as have just been given for the windows south-east of Dehra. Whatever doubts may be raised about these inferred windows, it is difficult, however, to escape the conclusion that the zig-zag disposition of the Simla slates—Nummulitic—Blaini-Krol rocks between Solon and Subathu represents the result of erosion of two tectonic units that had been brought together by thrust movements and were later folded. Here again, in a manner comparable to the windows already described south-east of Dehra, the contrasts between the Simla slates at the base of the Tertiaries and the Blaini slates above them is striking, precluding any explanation by simple infolding of Nummulitics within a single slate series.

(3) On the north-east side of the Krol syncline Nummulitics occur at Sayasu and Dabra, as has been already mentioned (page 417). They overlie Simla slates and appear to underlie the complex group of Chandpurs and Mandhalis. By Koruwa (30° 40′ : 77° 51′), and on the col south-east of Kailana, are found shattered and glazed quartzites exactly similar to those associated with the Nummulitics of the windows between Dehra and Rikhikesh, and around Banas Malla (29° 57′ : 78° 21′), again overlying Simla slates and underlying Mandhali limestones. The thrust which separates the Chandpur-Mandhali rocks from the Simla slates dips southwards, below the Krol syncline. It has been called the Tons thrust and I consider it almost certain that this thrust joins up below the Krol syncline with the north-dipping Krol Thrust on the south side. There is evidence for this supposition along the Huinl river in Tehri Garhwal.

Considering only the first two areas, the minimum displacement of the Krol Thrust and Nappe would be about five miles. Taking into consideration the region on the north side of the Krol syncline

near Kailana, the minimum displacement is likely to be 20 miles (32 km.).

Metamorphism.

A point which should be emphasised in connection with the Chandpur and Nagthat series of the Krol Nappe is the increase in metamorphism which is observable from the south-west towards the north-east. Along the south-west side of the Mussoorie syncline, for example near Paled (30° 17′ : 78° 11′), the Chandpur series is in the condition of banded green slates and ash beds, while the Nagthat series is made up of soft sandstones and quartzites with a secondary silica cement. Towards the north-east both these series develop schistosity. The Chandpur slates are changed to schistose chlorite-sericite-phyllites, as at Jugargaon (30° 23′ : 78° 24′), while the arenaceous beds of the Nagthat series become schistose chlorite-sericite-quartzites, such as are well seen in the neighbourhood of Kaudia (30° 25′ : 78° 22′). The distance separating these contrasted grades of metamorphism is about 10 miles.

3. Garhwal Nappes.

1. OUTLIERS IN TEHRI GARHWAL STATE.

Ever since I had read Middlemiss's paper on the Physical Geology of West British Garhwal, I had hoped to find a structure in the centres of synclines in Sirmur State and Tehri Garhwal comparable to the one he had described, for I was convinced that the Massive limestone and Tal beds of Middlemiss were equivalent to the Krol limestone and the presumed Tals in Sirmur State. In 1931 a sandy current-bedded limestone was found at the top of the Tal series along the Nigali Dhar of Sirmur State (30° 39′ : 77° 34′) but unfortunately this was the highest horizon exposed[1]. It was not until March 1935 that the expected structure was found at the top of the Tal succession of the Mussoorie syncline on hill 6533 (30° 22′ : 78° 12′). Between Tashla (30° 22′ : 78° 11′), Satengal (30° 21′ : 78° 13′) and Hatwalgaon (30° 20′ : 78° 16′), there was found an outlier of schistose phyllites and subordinate white quartzites overlying a group of limestones, slates and boulder beds, both of which units rest upon and are surrounded by the Tal series. The

[1] *Rec. Geol. Sur. Ind.*, LXVII, Pl. 23, (1934).

area covered by this outlier is about 7 square miles. Equally convincing is another outlier of schistose phyllites lying upon the Tal series around Banali (30° 18′ : 78° 17′ 30″). This outlier is two square miles in area. Both outliers indisputably rest upon Tal beds with centripetal dips varying from 20° to 45°. Adjacent to the Banali outlier is a still smaller outlier, about 200,000 square yards in area, lying as a thin coating upon the Tal quartzites.

It is quite impossible to explain the position of the schistose phyllites upon the Tal series by ring-shaped reversed faults descending through the whole of the 17,000 feet of rocks of the Krol Nappe here present to its basement.

The Satengal outlier is complicated by the presence in its western part of slates, boulder beds, and a limestone identical to the Bansa limestone, which occur between the schistose phyllites and the underlying Tals. Nevertheless, whatever the stratigraphical position of these intervening beds may be, the fact of an overthrust of schistose phyllites upon the Tals is clear and beyond dispute. There is no such complication in the eastern part of the Satengal outlier or at Banali, where the schistose rocks lie directly upon the Tal series, locally with an angular discordance. I showed the Banali outlier to Professor Arnold Heim and Doctor Gansser, both of whom agreed that no doubt could be raised as to its overthrust nature.

The characteristic rock of these outliers is a green schistose chlorite-sericite-phyllite, with segregations of secondary chlorite in streaks. This type can be exactly matched with the rocks at the base of the Krol Nappe around Jugargaon (page 421). The fact that the underlying Tal and Nagthat quartzites are not inverted proves that the schistose phyllites of the outliers above them do not rest in that position as a result of duplication of the Chandpurs which occur at the base of the Krol Nappe by recumbent folding. If recumbent folding were present, either the Tal quartzites or the Nagthat quartzites should be inverted. Further indication of the lack of inversion is suggested by the presence of the limestone, mentioned above, which is similar to the Bansa limestone, and of boulder beds below the schistose phyllites of the Satengal outlier. This relationship is the same as that obtaining in the rocks at the base of the Krol Nappe between Kalsi and Chakrata, where the Bansa limestone and Mandhalis appear to underlie the Chandpur series. That is to say, both in the Krol Nappe and in the Garhwal

Nappe, there is the same succession upwards of these beds. The relationship is, it may be accepted, one of a thrust contact of the metamorphosed type of Chandpurs upon normally lying Tal beds.

In these two outliers of Tehri Garhwal there are two desirable features for demonstrating the complete overthrust of the schistose phyllites upon the Tal series :—

(1) Dips are everywhere centripetally inclined, but are not steep enough to bring the base of the schistose phyllites below the level of river erosion ;

(2) the two areas are of a size small enough to be seen almost as a whole by the eye from neighbouring peaks, so that the results of detailed mapping of the thrust boundary may be confirmed and integrated at a single glance.

2. OUTLIERS IN BRITISH GARHWAL.

In coming to the area mapped by Middlemiss in British Garhwal, these two features are absent. Dips are on the whole steeper, and the area is so large that it cannot be taken in by inspection from any one vantage point. I have re-mapped that part of Middlemiss's area which lies in sheet 53 J/S.W., and have traversed along the Nayar river from Byansghat to Bhanghat, Dwarikhal, Lansdowne (29° 51′ : 78° 41′) and Dogadda. The correlations given in table 2 are definitely proved by the results of detailed mapping. The only difference between the Garhwal area and that of Tehri Garhwal is that Nummulitics are present above the Tal series in Garhwal, while they are almost absent from Tehri Garhwal except for very narrow outcrops along the Ganges river. The outcrop of Nummulitics in Garhwal is discontinuous, but is slightly more extensive than shown by Middlemiss.

Overlying the Nummulitics in sheet 53 J/S.W. occur two separate nappes which are disposed in synclines that are separated for some distance by the anticlinal axis running from just east of Lachmanjhula in a south-east direction past Jogyana along the Huill river; Section 2. In the western, Amri, syncline (Amri : 30° 04′ : 78° 22′) the rocks are characteristically green schistose phyllites with subordinate white schistose quartzites, the assemblage recalling at once that of the Satengal and Banali outliers. In the eastern, Bijni, syncline (Bijni : 30° 04′ : 78° 25′) the dominant rocks are purple, green, and white quartzites exactly resembling the Nagthat series,

with underlying and subordinate banded green slates similar to those of the less metamorphosed type of Chandpurs on the south-west side of the Krol Nappe. In the anticline separating these two nappes there crops out a complicated assemblage of Tal and Nummulitic rocks, obviously highly disturbed and interfolded, as may be well seen at Bagurgaon (29° 58′ : 78° 29′).

Between Kothar (29° 58′ : 78° 34′) and Lansdowne there is another and larger syncline of schistose phyllites and white schistose quartzites, similar to those of the Amri, Banali and Satengal synclinal outliers. Intruded into these rocks occurs the gneissic granite of Lansdowne.

It must be admitted at once that there are many difficulties in understanding the Garhwal area. Firstly, I have been able to come to no satisfactory conclusion about the true position of the boulder slate (volcanic breccia of Middlemiss). In the north end of the Garhwal syncline this boulder slate unquestionably joins up with the Blaini, but I am uncertain if the boulder slate so often found lying above the Tal beds of Garhwal is the same as the Blaini. thrust upon the Tals, or if it is an altogether different horizon Secondly, as seen above, the outcrop of Middlemiss's Inner Schistose series is not made up of a single tectonic unit. These difficulties can only be cleared up by detailed mapping, but, in spite of them, I am confident that the Inner Schistose series of Middlemiss does truly overlie the Nummulitic, Tal and Krol rocks as a thrust outlier. In no other way is it possible to explain the ring-shaped boundary between the older rocks and the Nummulitics around Amri and Palyalgaon (30° 06′ : 78° 24′). Just north of Amri, Middlemiss mapped two faults separating the older rocks from the Nummulitics. The N.W.-S.E. fault is shown as terminating westwards against the N.-S. fault, which is made to pass northwards towards Patna, *without displacing the Nummulitic—Tal boundary.* On the postulate of Middlemiss, this fault should have caused the Outer Formations to be thrown down below their own basement. Its throw would be enormous, and yet it fails to displace the Nummulitic—Tal boundary at all. A re-examination of this area has shown that the schistose phyllites overlie the Nummulitics round an arc of 180° and that the boundary between them is continuous and not made up of the intersection of two or more faults. The reason is clear. The faulted junction between the schistose phyllites of Amri and the Nummulitics does not cut through the Nummulitics

and underlying formations, because it is a thrust plane which lies at an horizon altogether above them; Plate 35 and Plate 37, fig. 2.

Moreover, in the Garhwal area the rock types of the Inner Schistose series are dissimilar to those underlying the Krol series along the Nayar river, both in lithology and in strike. Underlying the Krols from Byansghat to Banghat (29° 57′ : 78° 42′) occur Simla slates with strikes varying from E.-W. to N.N.E.-S.S.W. The Krol—Tal rocks, and the overlying schistose rocks from Dwarikhal to Lansdowne, have a uniform N.W.-S.E. strike. The Simla slates also differ in lithology and degree of metamorphism from the rocks of the schistose series overlying the Krol and Tal series. On the interpretation of Middlemiss, the Simla slates and the Inner Schistose series should be the same, since the reverse faulting which he postulated would have brought up the same foundation rocks upon the Tals as underlie the Tal and Krol series.

It is difficult to picture the mechanics of the reversed faulting suggested by Middlemiss, since it is necessary to assume either that his Outer series have been thrust inwards and downwards towards a centre or that his Inner series has expanded outwards on all sides from a centre over the Outer series. Cone fractures are common features in certain volcanic areas such as the western islands of Scotland, but so far as I know the displacement along these fractures is inconsiderable and is largely a consequence of infilling with magma. The whole difficulty is removed if we accept that the present basin-like disposition is a secondary feature subsequently impressed upon an extensive thrust of the Garhwal units over the Krol unit.

In connection with the question of reversed faulting, I think that Mallet had a truer grasp of the solid geometry required by geological relationships similar to those of Garhwal. When mapping north Bengal and southern Sikkim he realised that the position of the Darjeeling gneiss above the Daling series could not be explained by 'mere local inversion along the lines of contact'[1]. So for as I have seen these rocks in eastern Nepal and Sikkim, the Darjeeling gneiss, though truly above the Daling series, does not appear to be separated from it by a thrust plane[2]. The point it is wished to emphasise here is that both in Garhwal and in eastern Nepal and Sikkim the observed relationship is one involving

[1] Mallet, F. R., *Mem. Geol. Surv. Ind.*, XI, p. 42, (1874).
[2] Auden, J. B., *Rec. Geol. Surv. Ind.*, LXIX, p. 161, (1935).

complete superposition and not local reversed faulting, even though the explanation offered for the manner of this superposition is different in the two cases.

The argument for an extensive thrust plane over the Nummulitic, Tal and Krol rocks of Garhwal may now be summarised.

(1) The Nummulitic, Tal and Krol rocks of Garhwal completely surround the Inner Schistose series (as shown by Middlemiss) and dip below them centripetally. This is well seen around Amri and Palyalgaon in sheet 53 J/S. W.

(2) At Satengal and Banali in Tehri Garhwal State, schistose phyllites lie as indisputable thrust outliers upon the Tal series.

(3) At least two synclines occur within the Inner Schistose series of Garhwal (those of Amri and Lansdowne) in which the schistose rocks are identical in every respect to those found in the indisputable overthrust outliers of Satengal and Banali. In the Lansdowne outlier there is an additional element in the presence of the gneissic granite, which was intruded before the thrust movements had taken place.

(4) Middlemiss argued on the grounds of metamorphism that the schistose series are older than the Nummulitics upon which they lie. Apart from the question of metamorphism, there is no known post-Nummulitic sequence to correspond to the schistose series. From both points of view the schistose series must lie with an abnormal contact upon the Nummulitics and Tal series.

(5) The Inner Schistose series is composed of two main units:—

(*a*) schistose phyllites, slates, schistose quartzites and quartzites, resembling the more metamorphosed facies of the Chandpur series of the Krol Nappe:

(*b*) banded grey-green slates and mainly purple quartzites, resembling the less metamorphosed facies of the Chandpur and Nagthat series of the Krol Nappe.

Neither of these two units resembles, in strike or closely in lithology, the Simla slates which occur at the base of the Outer series along the Nayar river. The more schistose rocks of the Inner series also differ from the Simla slates in metamorphic grade. These facts appear to negative the explanation given by Middlemiss of reversed faulting having brought up the basement of the Outer Formations so as to lie upon them. If reversed faulting had taken place, the basement rocks (Simla slates along the Nayar river) and

the Inner Schistose series should be identical. In the solution suggested in this paper it is believed that the facts are best explained by two thrusts: the Garhwal Thrusts introducing rocks similar to those which in parts of sheet 53 J/S.W. lie at the base of the Krol Nappe, so as to rest above the Krol Nappe: and the Krol Thrust dividing off the Krol Nappe from the Simla slate foundation. This thrust is believed to be transgressive, both towards the south-east in Garhwal, and towards the north-west in Sirmur and Baghat States, with the result that it cuts out successive members from the base of the Krol Nappe.

I would suggest that the arguments given above are sufficient to establish the existence of a great system of thrusts upon the Nagthat-Blaini-Krol-Tal-Nummulitic succession in Tehri Garhwal and British Garhwal. These thrust-nappes exist now as three outliers:—

(1) Satengal outlier, covering about 7 square miles;
(2) Banali outlier, covering 2 square miles;
(3) Garhwal outlier, covering approximately 240 square miles.

The Bijni Nappe is possibly relatively local in origin, but the main nappe of the Garhwal system, which includes the Satengal and Banali outliers, and the Amri and Lansdowne synclines in the Garhwal outlier, has certainly travelled a great distance.

3. FURTHER OUTLIERS OF THE GARHWAL NAPPES.

Besides working in the Lansdowne area of British Garhwal, Middlemiss also mapped a syncline of schists and quartzites intruded by gneissic granite at Dudatoli (30° 03′ : 79° 12′)[1]. He pointed out (page 40) the exact similarity between the gneissic granites of Dudatoli and Lansdowne, and also (page 136) the fact that the only synclines of importance along a line from the Plains to the Main Himalayan Range are connected with the gneissose and schistose series. I would go further in believing that the schistose rocks into which the Dudatoli granite is intruded are the same as those of Lansdowne, Amri, Banali and Satengal, which have already been described. Similarly, the gneissic granite of Ranikhet and Dwarahat is intruded into phyllites of the same type.

There is no evidence in the regions in which I have mapped or traversed for the equivalent of the Jutogh series of Simla described

[1] *Rec. Geol. Surv. Ind.*, XX, pp. 40, 136, (1887).

by Pilgrim and West. The granites of Lansdowne, Dudatoli, Dwarahat and Ranikhet appear in all cases to be intruded into phyllites of one type, corresponding to the more metamorphosed facies of the Chandpurs. These rocks may possibly be equivalent to the Chail series of West. The local increase in metamorphism to garnet-chlorite-phyllite, garnet-chlorite-schist, fine-grained biotite-schist, chiastolite schist, which is attributable to contact effects in proximity to the intruded granites, appears to take place in the Chandpur series of schistose phyllites and not in a higher and altogether distinct series such as the Jutoghs of Simla. This fact I can state with certainty to be true of the Lansdowne area where it is definite that there is no additional series above the Chandpurs of the Inner Schistose group. My briefer examination of the Dwarahat-Dudatoli area suggests the same conclusion, one which seems inevitable indeed from the observations of Middlemiss, mentioned in the passage which I have quoted in an earlier paper[2]. In this passage he points out the gradation in a single series from schist to ordinary slate. Mr. West, in a recent discussion of this problem, accepted that the Jutogh Thrust may not be of widespread significance towards the south-east[3].

In all these cases, the schistose rocks, with or without intruded granite, appear to overlie in synclinal form less metamorphosed limestones and quartzites. Consequently, besides the three outliers of the Garhwal Nappes which I have discussed in detail above, I would suggest that the Dudatoli-Dwarahat-Ranikhet-Almora region also represents a syncline or group of synclines which may be outliers of the Garhwal Nappes. In the map (Plate 36) only one generalised syncline has been shown, since no detailed mapping has been done in this area, except by Middlemiss around Dudatoli.

4. Age of the Krol and Garhwal Thrusts.

The maximum age of the Krol Thrust is established by the presence below it of Nummulitic and Dagshai rocks. This thrust cannot, therefore, be older than Burdigalian.

Below the Garhwal Thrusts occur Nummulitics and possible Dagshai rocks. These thrusts are therefore certainly younger than

[1] *Rec. Geol. Surv. Ind.*, XX, p. 137, (1887).
[2] *Op. cit.*, LXVII, p. 412, (1934).
[3] *Current Science*, III, p. , (1935).

the Eocene, and are possibly, as in the case of the Krol Thrust, not older than Miocene in age. This is in agreement with the recent discovery of Nummulitic and Dagshai rocks by Mr. West in the Shali area, below the Chail Thrust[1].

Since no Siwalik rocks are found in the windows, or below the outliers, it might be assumed that the thrust movements took place after the Burdigalian but before the Siwaliks had time to be deposited there, an assumption which would make the movement about Helvetian in age. If, however, the Siwaliks never extended so far to the north-east, this argument fails, since it is possible to imagine the thrusting to have occurred a considerable time after the Nummulitics and Dagshais had been laid down and while the Siwaliks were being deposited elsewhere.

That some of the movement along the Krol Thrust is more recent than Helvetian is proved by the frequent juxtaposition of pre-Tertiaries upon the Nahans between the Jumna river and north Bengal. Further, in places even the Upper Siwalik conglomerates are involved in overthrust by the pre-Tertiaries. Ten miles north-west of Dehra the boulders of these conglomerates are so shattered that it is impossible to obtain a hand specimen of them. Similar overthrusting occurs at Bilaspur on the Sutlej river (31° 20′ : 76° 45′)[2]. These movements must be of Lower Pleistocene or even of later age. Yet it is difficult to believe that the major horizontal movements of the Krol and Garhwal Nappes over a distance of several miles took place as late as this. By Lower Pleistocene times, the rising Himalayan chain must have been dissected to such an extent into blocks by deeply eroding streams that the upper nappes had already been worn away into outliers. The formation of these upper nappes can only have taken place before erosion had proceeded to such an extent that the outcrops of the nappes along an alignment in the direction of movement had been divided off into separate outliers, unable to translate the stresses as a unit. Both the Krol and Garhwal Nappes have been strongly folded, possibly as a result of the resistance offered by the floor upon which the movement was effected. There has since been erosion of these thrusts with the resulting formation of the windows and zig-zag outcrops, and it may be accepted that the major part of the movement along these thrusts took place before river dissection had

[1] *Rec. Geol. Surv. Ind.*, LXXI, p. 72, (1937).
[2] *Op. cit.*, LXVII, p. 444, (1934).

reached its present pronounced stage. It may, therefore, be assumed that there has been more than one period of movement, the stronger movements perhaps during the Helvetian, and the later movements during the Siwalik and post-Siwalik.

IV. SNOWY RANGES.

I have visited the higher Himalaya of this region twice; in 1932, when a traverse was made up the Alaknanda valley to Badrinath, Mana and the Arwa valley: and in 1935, when the Bhagirathi valley was ascended up to some of its tributary valleys in the neighbourhood of Harsil, Gangotri and Gaumukh. A brief lithological description of the rocks encountered along the Alaknanda valley has already appeared[1]. It is intended here to mention only a few points concerned with the snowy ranges of the higher Himalaya.

Two main zones.

The snowy ranges between the Bhagirathi and Alaknanda valleys may be divided into two zones by a fairly well defined line. The southern zone, forming the Main Himalayan Range as seen from Landour and Lansdowne, consists predominantly of paragneisses and schists, dipping towards the north-east, and presenting a scarp face towards the Plains of India. The northern zone is of granite, out of which the peaks in the Gangotri and Arwa basins are carved. The boundary between these two zones is shown on the map (Plate 37). I disagree with the mapping of Griesbach, who has drawn in the neighbourhood of Harsil and Dharali what appears to me to be an artificial boundary between Haimanta slates and a combined group of granite and metamorphics[2].

Metamorphics of the Main Himalayan Range.

The rocks of the Main Himalayan Range consist of a varied assemblage of schistose phyllites, schists, and granulites intruded by gneissic granite and pegmatite. They rest upon little metamorphosed shales, phyllites, limestones and quartzites, from which they are separated by a thrust plane. This thrust is well seen at Sini (30° 46′ : 78° 36′) and occurs near mile 158 on the pilgrim track from Hardwar to Badrinath. The rocks immediately above the thrust

[1] *Rec. Geol. Surv. Ind.*, LXIX, p. 133, (1935).
[2] *Mem. Geol. Surv. Ind.*, XXIII, (1891).

appear similar to those of the metamorphosed Chandpur series found in some places at the base of the Krol Nappe and more generally in the main Garhwal Nappe.

The main suite of metamorphosed sediments must belong to a different unit. The rocks of this suite were originally shales shaly sandstones, sandstones, calcareous shales and limestones. In their present metamorphic condition they form a series that is characteristically granulitic, consisting of quartz-biotite-granulites, often with garnet and felspars, quartzites, hornblende-granulites, diopside-calciphyres, marbles, biotite-garnet-schists and kyanite-schists. The calcareous rocks are best developed between Badrinath and Mana, but occur to some extent up the Rudagaira valley (30° 55′ : 78° 51′). It is possible that this suite is equivalent to the Jutogh series of Simla.

Granite zone.

The granites to the north of the Main Himalayan Range probably occur continuously from Dharali (31° 02′ : 78° 47′) eastwards to the Saraswati valley and Kamet peak. Several types of granite are present including muscovite-tourmaline-granite, biotite-muscovite-granite and adamellite. Porphyritic types are common at Bhaironghati, Jangla and up the Nela (Lamkaga) valley.

Some of these granites are sheared and crushed. The presence of patches of granular blue quartz is suggestive of crushing, a fact which struck my colleague Dr. J. A. Dunn on being shown specimens. Shearing is well seen at a height of 10,300 feet up the Nela valley (about three miles from Harsil), where there is a contact between the granite and overlying metamorphics. The garnet of the metamorphics has broken down retrogressively to chlorite, while the granite has been sheared and mylonitised through a width of 150 feet at right angles to the plane of contact, with the development of marked schistosity and the destruction of the phenocrysts.

It would appear from these facts that some at least of these granites are not post-tectonic in the sense of the post-tectonic granites which cut across the *decken* in the Alps. These strained granites may have been intruded either during the major thrust movements, or at an altogether earlier period. It was considered above that the Lansdowne granite was intruded before the formation of the Garhwal Thrust and that it was pre-Miocene.

V. POSSIBLE NORTHWARD EXTENSION OF THE GARHWAL NAPPES.

It has been stated that the main Garhwal Nappe occurs as synclinal outliers resting upon less metamorphosed rocks. Reasons have been brought forward for regarding the schistose rocks and granite of Dudatoli as belonging to the same overthrust unit as those of the Satengal, Banali, Amri and Lansdowne outliers. The nearest schistose rocks to the north-east from Dudatoli occur at the base of the Main Himalayan Range, where they too appear to lie with a thrust contact upon less altered limestones, quartzites and slates. It would seem possible, therefore, that the main Garhwal Nappe joins up with the rocks at the base of the Main Himalayan Range and that the minimum distance of translation of this tectonic unit may be about 50 miles (80 km.). It appears that the granites were intruded principally into the Garhwal and overlying units and were thrust with them for miles towards the south-west, over rocks which are free from granitic intrusions, but are in places considerably injected with basic magma.

Finally, comparison may be made with the eastern Himalaya. In eastern Nepal and north Bengal there are two main dislocations :—

(1) the thrust causing the Gondwana rocks to lie upon the Siwaliks :

(2) the thrust separating the Daling series from the underlying Gondwanas.

These two thrusts may be analogous respectively to the Krol Thrust and one of the Garhwal Thrusts. Near Udaipur Garhi (26° 57′ : 86° 32′) there are bleaching carbonaceous slates and a dark crystalline limestone which resemble the Blaini and Krol series of the western Himalaya, and which, like them, rest upon Siwalik rocks.[1] Further, it may be remarked that the schistose phyllites of the main Garhwal Nappe appear to be identical to the Daling series of Nepal and Sikkim. In both areas, these schistose rocks are thrust upon Gondwanas or the equivalent of Gondwanas.

VI. EXPLANATION OF PLATES.

PLATE 35.—Map No. 53 J/S. W., reduced to the scale of 1 inch =4 miles, showing the disposition of the main tectonic units in the neighbourhood of Dehra and Rikhikesh.

[1] *Rec. Geol. Surv. Ind.*, LXIX, p. 143, (1935).

PLATE 36.—Tectonic Sketch Map of the Garhwal Himalaya, including a portion of 1 : million map No. 53. This map is based on the surveys and traverses of C. S. Middlemiss, C. L. Griesbach, and J. B. Auden. Auden alone is responsible for the tectonic interpretation of the geological results. The limits of the inferred Garhwal Nappe between Dudatoli and Ranikhet are conjectural.

PLATE 37, FIG. 1.—Section across Siwalik Range and Lower Himalaya in 1″ 2 miles map No. 53 J/S.W.

FIG. 2.—Section across the composite Garhwal Syncline showing Amri and Bijni Nappes and the unconformity below the upper Tal Calc. grit. (Scale 1″=1 mile.)

FIG. 3.—Tectonic section across the Garhwal Himalaya. A preliminary attempt. (Scale 1″=8 miles.)

MISCELLANEOUS NOTES.

An inclusion of coaly shale in Deccan Trap at Indore, Central India.

Discovery of inclusion.

In July, 1934, the Director of the Institute of Plant Industry sent a sample of 'coal' discovered at a depth of 19 feet from the surface as an inclusion in 'black trap rock' at Indore (22° 43′ : 75° 51′), Central India, during blasting operations in the course of digging a well.

Analyses.

Dr. M. S. Krishnan, who was Curator of the Geological Museum at that time, reported the specimen as 'shaly coal, dull black in colour and showing fine bright streaks of material (presumably of the nature of vitrain)'. It was analysed in this laboratory with the following results, an analysis by Mr. Y. Wad, Chemist to the Institute of Plant Industry, being given for purposes of comparison :—

	Per cent.	Per cent.
Moisture	2·80	..
Volatile matter	20·23	16·595
Fixed carbon	18·92	..
Ash	58·05	58·03
	100·00	
Specific gravity	1·88	2·04
Caking properties	Does not cake	..
Colour of ash	Pink-buff	..
Analyst	Mahadeo Ram	Y. Wad.

The specimen is thus a coaly shale as it contains more than 50 per cent. ash.[1] The powdered mass is registered as N. 857 in the collections of this Department.

Further details of mode of occurrence.

Further correspondence elicited the information that the size of the coaly shale as found was approximately 12 inches × 15 inches × 9 inches. As the well in which the inclusion was found was full of water, it was not possible to send specimens of the rock in which it was embedded until March. 1935, when specimens of trap from above and below the coaly shale were received from Indore.

[1] Fermor, L. L., *Rec. Geol. Surv. Ind.*, LX, p. 345, (1928).

These were collected in the well at depths of 18 feet (47/867, 23888), 21 feet (47/868, 23889), and 23 feet (47/869, 23890) respectively, the first being above the site of the inclusion, and the two latter below it.

Examination of specimens and sections of trap.

The specimens and sections were examined by Sir Lewis Fermor who stated :—'The specimens of both the overlying trap are of porphyritic basalt containing not only abundant phenocrysts of plagioclase, but also altered phenocrysts of olivine, now completely altered to what is probably delessite, with iddingsite in one case. They might be parts of the same flow, the highest specimens showing vesicular tendencies.'

Additional sections of trap.

As a result of doubts as to the authenticity of the occurrence, advantage was taken of the visits of Mr. W. D. West to Indore in connection with the Indian Science Congress, and he was requested kindly to examine the well in question. Mr. West stated :—

'When I visited Indore in October, 1935, the water-level in the well was too high for me to see anything. In January, 1936, however, the water-level was about 25 feet below ground-level. Thanks to Mr. F. K. Jackson, in whose compound the well is, I was able to descend into the well by sitting on a *charpoy* which was let down with ropes. This gave me a good view of the sides of the well all round.

It is quite clear that there is now no trace of coaly shale anywhere in the sides of the well. The information at Indore suggested that the coaly shale was a large "lump" situated towards one side of the well, and not a seam. It occurred 19 feet down. My own observations showed that the sides of the well are entirely trap, and it is clear that the whole of the coaly shale must have been removed when the well was sunk.

Examination of the sides of the well suggested that there might have been a flow junction at 16½ feet down. At this level, there was rather a sharp line all round the well, below which the trap was very "platy" for six or eight inches, while above and below it was more massive. I could see no abundant vesicles near this point.

Cursory examination of the microscope slides (24496-24499) of the rock above and below the possible junction showed that there are slight differences in the rocks, but I did not have time before

leaving for camp to examine the slides very thoroughly. There was nothing to suggest it was a dyke.

There is no doubt whatever regarding the authenticity of the discovery. Unfortunately there is no more of the rock left at Indore.'

Various theories have been put forward to explain this occurrence, but the one that seems to have most support is that the inclusion is part of an intertrappean shale caught up by a trap flow. Whatever the origin, the occurrence has great interest, and for this reason it is recorded herewith.

Possible origin.

A. L. COULSON.

Octahedral Pyrite Crystals from the Kohat District, North-West Frontier Province.

My colleague, Dr. J. A. Dunn, identified as pyrite certain small, slightly distorted, octahedral crystals which I had given me at Kark (formerly Kharak; 33° 7′ : 71° 5′ 30″) in the Kohat district, North-West Frontier Province, when I was inspecting the local oil-shale occurrences in January, 1936. The crystals are found commonly along the Tarkha Algad near Kark in a ?Laki gypseous series overlying the salt marl and are collected by the local small boys. The largest crystals have axes of 7-8 mm., but most crystals have axes of about 5-6 mm.

After the thin göthite covering had been removed by sandpaper from its faces, Mr. P. C. Roy kindly analysed one of the crystals of pyrite for me in the Laboratory of the Geological Survey of India with the following results:—

	Per cent.
Fe	47·09
S	52·40
	99·49

Dr. Dunn's polished section of a crystal showed no traces of magnetite but thin veins of göthite which were irregular in places and then followed cleavage planes. This göthite would account for the high percentage of iron, theoretical pyrite having 46·6 per cent. of iron and 53·4 per cent. of sulphur. A small amount of water must also be present.

Pyrite, of course, is a common mineral in the gypseous series referred to above, and its presence has been recorded often by Wynne and Pascoe amongst others. No reference seems to have been made, however, to crystal forms other than the cube and pyritohedron, though I have a recollection of reading of 'black diamonds', really pyrite crystals of octahedral shape, occurring in a series of age similar to the gypseous series at Kark.

Though Ford[1] says the octahedral form of pyrite is 'also common', almost perfect octahedra of that mineral are rare as there is usually a development of pyritohedral faces with the octahedral. Octahedra certainly occur in Pennsylvania,[2] accompanied by rarer forms with curved faces. Dr. Dunn has noted octahedral faces on pyrite crystals in Bawdwin ores from Burma and Mr. B. C. Gupta has shown me octahedal faces on pyrites in association with quartz and calcite from Kerakibari (25° 45′ : 74° 12′) in the Todgarh tahsil of Ajmer-Merwara.[3] However it would appear that the occurrence of these small octahedra of pyrite near Kark is worthy of record.

A. L. COULSON.

Quarterly Statistics of Production of Coal, Gold and Petroleum in India : July to September, 1936.

Coal.

—	July.	August.	September.	Quarterly total for each Province.
	Tons.	Tons.	Tons.	Tons.
Assam	18,218	17,783	15,994	51,995
Baluchistan	163	345	369	877
Bengal	465,455	524,006	602,413	1,591,874
Bihar	856,095	893,028	1,030,288	2,779,411
Orissa	3,003	1,692	2,475	7,170
Central Provinces	127,109	106,413	97,619	331,141
Punjab	4,306	4,418	10,615	19,339
TOTAL	1,474,349	1,547,685	1,759,773	4,781,807

[1] 'A Text-Book of Mineralogy', after Dana, p. 433, (1932).
[2] Penfield, *Amer. Journ. Sci.*, XXXVII, p. 209, (1889).
[3] *Mem. Geol. Surv. Ind.*, LXV, Pt. 2, p. 169, (1934).

Gold.

—	July.	August.	September.	Quarterly total for each Company.
	Ozs.	Ozs.	Ozs.	Ozs.
The Mysore Gold Mining Co., Ltd.	8,161	8,162	7,900	24,223
The Champion Reef Gold Mines of India, Ltd.	5,885	5,884	5,694	17,463
The Ooregam Gold Mining Company of India, Ltd.	4,349	4,338	4,379	13,066
The Nundydroog Mines, Ltd. .	9,635	9,637	9,619	28,891
TOTAL .	28,030	28,021	27,592	83,643

Petroleum.

—	Crude Petroleum.	Total gasolene from natural gas.*
	Gallons.	Gallons.
Assam	16,353,632	*Nil.*
Burma	67,489,517	2,222,493
Punjab	996,720	114,606
TOTAL .	84,839,869	2,337,099

* These figures represent the total amounts of gasolene derived from natural gas at the well-head. Of these amounts, a portion is sold locally as 'petrol' and the remainder is mixed with the crude petroleum and sent to the refineries. The figures given in the two columns, therefore, together represent the total 'raw products' obtained. These remarks apply to the similar totals quoted in previous *Records.*

A. M. HERON.

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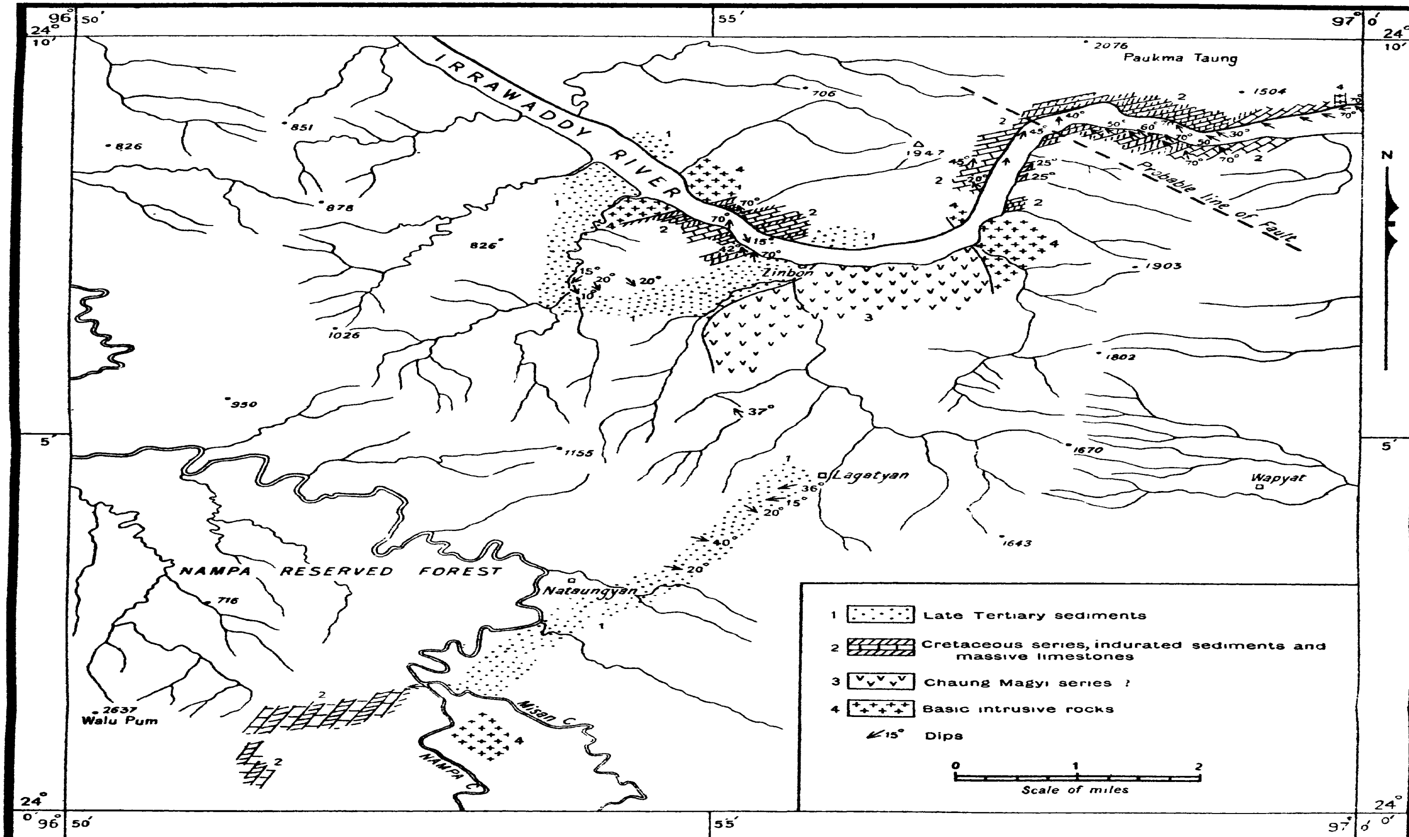

P. N. Bose, del.

G. S. I., Calcutta.

GEOLOGICAL SKETCH MAP OF SECOND DEFILE OF IRRAWADDY RIVER BELOW BHAMO.

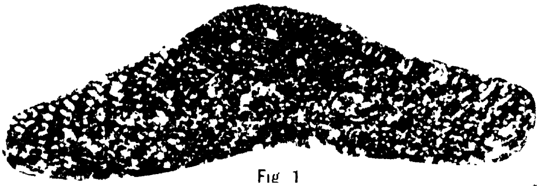

Fig 1

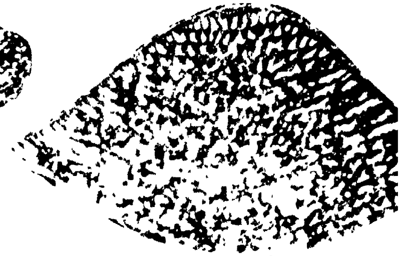

Fig. 4.

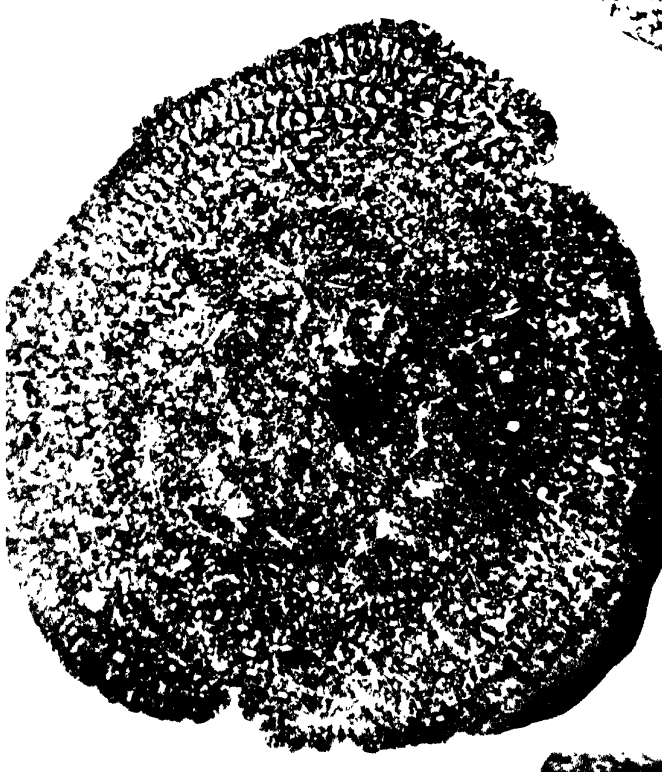

Fig 2.

Fig. 5

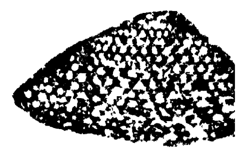

Fig 6

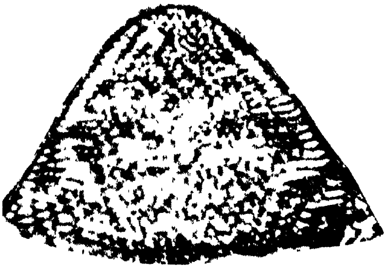

Fig. 3.

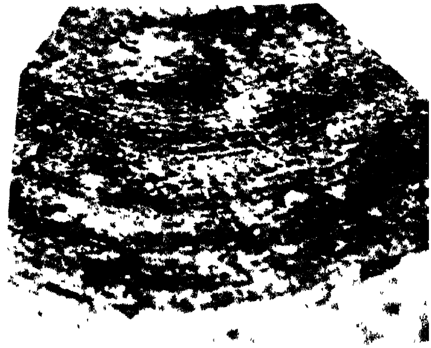

Fig. 7.

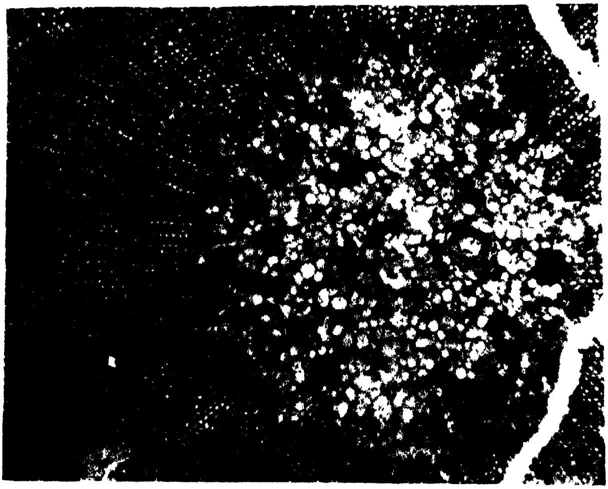

Fig. 1 (× 35)

Fig 4 (× ca 235)

Fig 5 (× ca 235).

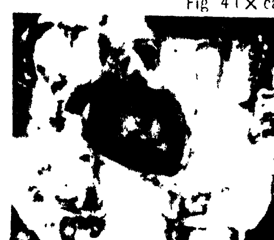

Fig 6 (× ca 118)

Fig. 2 (× ca 200)

Fig 3 (× 32)

K. N. Kaul, Photo *G. S. I., Calcutta*

MESEMBRIOXYLON SHANENSE, *sp. nov.*

Fig. 1 (× 100).

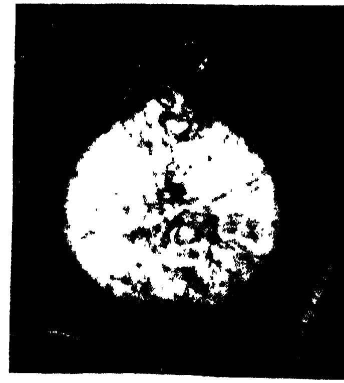

Fig. 2 (× 100)

Fig. 3 (× 50).

Fig. 4 (× 100).

Fig. 5 (× 120).

Fig. 6 (× 150).

Fig. 7 (× 100).

Fig. 8.

Fig. 9 (× 60).

S. R. N. Rao & K. S. Rao, Photos. *G. S. I., Calcutta*

FORAMINIFERA FROM INTER-TRAPPEAN BEDS NEAR RAJAHMUNDRY.

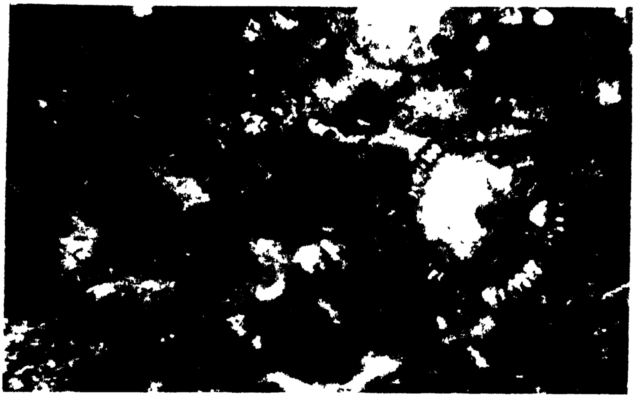

FIG. 1 SECTION OF PAUGADI LIMESTONE SHOWING SPHEROIDINELLA *sp.*, GLOBOTRUNCANA, *sp.*, AND CALCAREOUS ALGA, ACICULARIA. (× 80)

K. N. Rao & K. S. Rao, Photos. *G. S. I., Calcutta*

FIG. 2. SECTION OF PAUGADI LIMESTONE SHOWING SPHEROIDINELLA, *sp.*, GLOBOTRUNCANA, *sp.*, AND CALCAREOUS ALGAE, NEOMERIS AND ACICULARIA. (× 50)

FIG. 1. EXPOSURE OF MALERI BEDS AT RAMPUR NEAR MALERI

N. K. N. Aiyengar, Photos *G. S. I., Calcutta.*

FIG. 2. SEARCHING FOR REPTILIAN FOSSILS AT MALERI.